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The nematode genus Hemicycliophora de Man, 1921 (Criconematidae) with a description of a new plant-parasitic species

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Micoletzky in 1925 found 18 specimens of a new species of nematode for which he erected the genus *Procriconema*. Besides the type species, *P. membranifera*, he included *P. aquaticum* Micoletzky, 1913 and *P. thienemanni* Schneider, 1925, within this new genus. Taylor (1936) in his monograph of the Criconematinae separated *Procriconema* from the genera *Paratylenchus, Criconema*, and *Criconemoides* due to the fact that *Procriconema* had 200 or more annules which were not retrorse and the stylet knobs were without forward pointing processes. Further additions to this genus were *P. straeleni* de Coninck, 1931 and *P. micoletzkyi* Goffart, 1948. Loos (1948) found females of *P. membranifera* in Ceylon jungle and patna soils which were associated with males of *Hemicycliophora typica* de Man, 1921. On the basis of this close association and upon the suggestion of Dr. T. Goodey of England, Loos regarded *Procriconema membranifera* to be a synonym of *Hemicycliophora typica* and transferred the other species of *Procriconema* to the genus *Hemicycliophora*. Loos also described a new species, *H. longicaudata* of which he found 5 males and 5 females. The findings of Loos are fairly strong evidence that *Hemicycliophora* and *Procriconema* are synonymous. It should be kept in mind, nevertheless, that the males which Loos found may not belong to the same genus as the females found with them. If this were true, then Micoletzky's *Procriconema* would again become valid. Goffart (1952) adhered to Loos's classification in his description of *Hemicycliophora micoletzkyi*.

In a greenhouse experiment, a mixed population of nematodes from soil sent from Sanford, Florida was introduced to potted celery plants. Within a few months, numerous specimens of a new species of *Hemicycliophora*, which was present in the original inoculum, were isolated from the soil within each pot. The abundance of material presented an excellent opportunity for the study of this new species and for its comparison with other members of this genus.[2] During the preparation of this paper, 2 specimens of this new species were also collected from tobacco soil near Littiz, Pennsylvania.

Genus *Hemicycliophora* de Man, 1921

DIAGNOSIS EMENDED.—Body length from 0.3 to 1.2 mm. Anterior end obtuse or flattened, tail broadly conical to attenuated, terminus rounded to acuminate. Cuticle heavily annulated with 200 to 400 unarmed annules which may be delicately ornamented (*H. aquaticum*). Lateral fields sometimes

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present. Molted larval cuticle retained by adult females of some species. Knobbed stylet long and slender without forward pointing processes, representing from 1/6th to 1/14th of total body length. Esophagus with convoluted esophageal canal between buccal stylet and elliptical valves of muscular metacorpus when stylet is retracted. Isthmus narrower than metacorpus. Posterior bulb of esophagus slim, nonmuscular, and rounded. Excretory pore in region of posterior bulb or posterior to it. Intestine poorly defined, vacuolated. Female reproductive organ monodelphic and prodelphic. Ovary outstretched or reflexed with single or rouble row of öocytes. Vulva conspicuous. Anus and rectum poorly defined. Phasmids not observed.

Males scarce with body shorter and narrower than female. Head obtuse or slightly set off, sometimes bearing 2 somewhat circular markings. Buccal stylet not observed. Esophagus indistinct. Intestine vacuolate. Reproductive organ short, monedelphic, and prodelphic. Spicules 2, large, semi-circular or straight in shape. Gubernaculum small, short, and simple. Bursa well developed. Phasmids not observed.

Type species.—*Hemicycliophora typica* de Man, 1921.

Key to species of *Hemicycliophora*

1. Length of female about 0.4 mm. ..... *H. straeleni* de Coninck, 1931
   Length of female greater than 0.4 mm. 2
2. Female with long attenuated tail 3
   Female tail more bluntly-conical, not long and attenuated as above 4
3. Length of buccal stylet 74-92 μ ..... *H. longicaudata* Loos, 1948
   Length of buccal stylet 132 μ ..... *H. micoletzkyi* Goffart, 1952
4. Cuticular annules each bearing a row of delicate, ovoid ornamentations ..... *H. aquaticum* Micoletzky, 1913
   Cuticular annules undecorated 5
5. Excretory pore situated well behind posterior bulb of esophagus, lateral field containing single longitudinal row of subcuticular, circular markings ..... *H. parvana* n. sp.
   Excretory pore situated in region of esophago-intestinal junction or indistinguishable 6
6. Lateral field consisting of 2 long rows of rectangular markings ..... *H. typica* de Man, 1921
   Lateral field absent ..... *H. thienemanni* Schneider, 1925

Hemicycliophora straeleni (de Coninck, 1931) Loos, 1948

Synonym.—*Procriconema straeleni* de Coninck, 1931

(No figure available)

2 ♀ : 0.37-0.38 mm.; a = 23.3-25.0; b = 3.7-4.5; c = 10.6; V = 80.82%

Body small, rather slim. Mean number of annules about 300. Buccal stylet extending through 55 annules as does region from vulva to terminus. Annules at middle of body 1.35-1.40 μ in width, on tail only 1 μ in width. Lateral field of 4 parallel, longitudinal lines uninterrupted by transverse striation; lateral ridges of 3.35 μ width starting at spear and extending to tail. Molted larval cuticle not retained by adult.

Anterior end without setae or papillae bearing narrow funnel-shaped structure with sclerotized walls possibly serving as stylet guide. Stylet slender and curved, 60 μ long, a little less that 1/6th of total body length. Posterior

portion of spear more heavily sclerotized than anterior portion, bearing 2-3 knobs. Esophageal lumen posterior to stylet convoluted to medial bulb. Large posterior esophageal bulb present. Nerve ring not observed. Excretory pore obscure, situated at apex of posterior bulb and without sclerotized walls. Structure of intestine indistinct. Female gonad prodelphic and monodelphic, structure obscure. Vagina sclerotized, penetrating to 3/4th of body diameter. Tail conical with terminus somewhat rounded. Anus obscure.

Males not observed.

DIAGNOSIS: Hemicycliophora easily distinguished from other species by difference in length (0.37-0.38 mm.), width of transverse annulation (1.35-1.40 μ), and length of spear in proportion to total body length (about 1/6th).

TYPE LOCALITY: Humid moss. Province of Liege, Belgium.

Hemicycliophora longicaudata Loos, 1948

Fig. 1, A-F

5 ♀ : 0.85-1.06 mm.; a = 24.9-28.8; b = 7.1-8.7; c = ?; V = 72.4-74.5%
5 ♂ : 0.74-0.82 mm.; a = 34.3-40.8; b = ? ; c = 7.7-8.6; T = 37%

FEMALE: Body tapering slightly towards head and to long, attenuated tail which is annulate almost to terminus. Cuticle with more than 200 large prominent annules bearing numerous faint, almost parallel longitudinal wavy lines which extend over entire surface of cervical region but are restricted posteriorly to two sublateral zones running length of body. Lateral fields not observed. Molted larval cuticle not retained by adult.

Head not offset, broad and flat; lip region slightly raised. Six lips faintly visible in face view, each with terminal papilla; amphids appear as two elongate slits. Stylet 74-92 μ long, sometimes slightly curved, bearing 3 knobs to which protractor muscles are attached on posterior portion. Anterior portion of stylet overlapping posterior portion forming distinct junction.

Esophageal lumen convoluted between stylet and valvular apparatus of median bulb when stylet is retracted. Posterior esophageal bulb slightly more than half of width of median bulb. Nerve ring overlapping isthmus midway between bulbs. Intestine vacuolate. Anus and rectum not observed.

Vulva conspicuous; vagina wide, cuticularized, extending inwards and forward. Ovary outstretched, anterior end laying well below posterior esophageal bulb. Uterus extending 4 body widths forward, terminating anteriorly with a spherical shaped swelling.

MALE: Males rare, showing marked sexual dimorphism in comparison to females. Body slightly shorter and much narrower than female, tapering slightly towards head and more markedly towards terminus similar to female. Head not set off, slightly more rounded than female head; lips amalgamated.

Cuticle bearing irregular sublateral lines as in female but less coarsely annulated. Anterior edge of first annule, adjacent to lips, concave. Excretory pore 130-135 μ from anterior end of body. Spear absent. Esophagus indistinct. Intestine vacuolate, its junction with esophagus not clearly defined.

Spicules 42-45 μ, elongate and almost straight; tapering evenly from base which is slightly expanded over 1/7th of spicule length. Gubernaculum small and inconspicuous. Bursa well developed, broad, with serrate edges and transverse striae. Tail measuring 89.9-102.3 μ.

DIAGNOSIS: *Hemicycliophora* distinguished from other species by the long attenuated tail and male spicules which are almost straight in contrast to semicircular male spicules of *H. typica*.

TYPE LOCALITY: Jungle and patna soils, Ceylon.

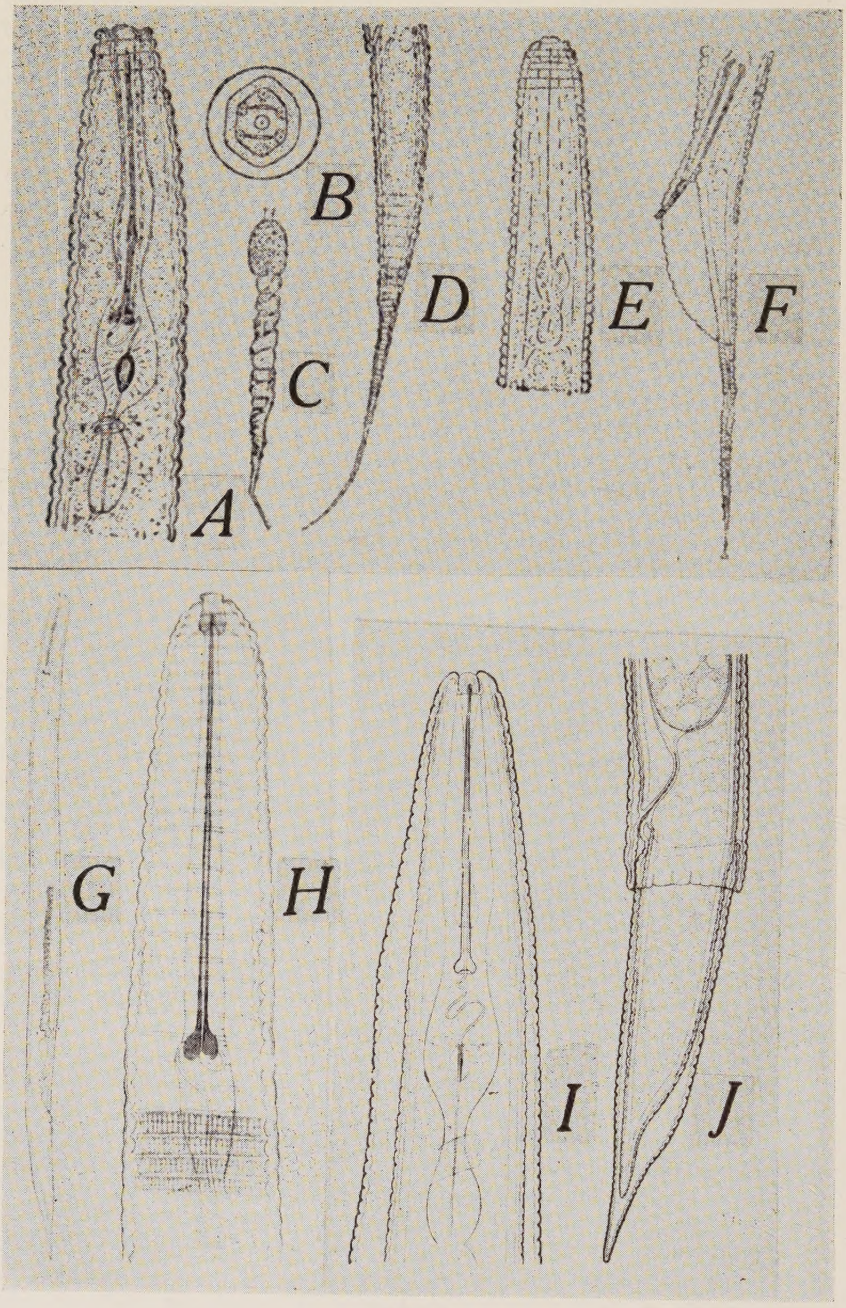

Fig. 1

Hemicycliophora aquaticum (Micoletzky, 1913) Loos, 1948
Synonyms—*Tylencholaimus aquaticus* Micoletzky, 1913;
Criconema aquaticum Micoletzky, 1917;
Hoplolaimus aquaticus Menzel, 1917;
Procriconema aquaticum Micoletzky, 1925

Fig. 1. G-H

1 immature ♀: 1.2 mm.; a = 22.2; b = 6.6; c = 5.1; V = 79%

Body plump, head rounded with set-off lip region containing hollow yellowish sclerotized structure consisting of three pieces possibly acting as stylet guide. Lips without papillae. Cuticle distinctly annulated and of 4 μ thickness. Number of annules about 290: buccal stylet extending through 36; region from anterior end to beginning of intestine extending through 56; and region from vulva to anus extending through about 60 annules. Cuticle composed of three layers: one thin, annulated distinctly at anterior and posterior end but otherwise only slightly crenate externally; a thick middle layer; and a delicate inner layer with annulations alternating with those of outer layer. Cuticular surface structure having very characteristic ornamentation of rows of delicate, elongate, ovoid markings. Lateral fields absent. Molted larval cuticle apparently retained by adult.

Knobbed, slender buccal stylet 140 μ long. Esophagus with muscular median bulb, posterior bulb obscure. Excretory pore not observed but apparently situated immediately posterior to median bulb of esophagus. Female gonad prodelphic and monodelphic. Uterus with posterior uterine branch extending 2/3rds the distance from vulva to obscure anus. Tail dorsally convex-conoid.

Males not observed.

DIAGNOSIS: *Hemicycliophora* immediately distinguished from other species by row of ovoid ornaments on surface of each annule.

TYPE LOCALITY: Water 13 m. deep, Fredericella region, Lunz Lake, Austria.

Hemicycliophora parvana n. sp.

Fig. 2 AA-I

12 ♀ : 1.11 mm. (1.03-1.15 mm.); a = 20.7 (19.6-22.3); b = 6.9 (6.5-7.5); c = 7.0 (6.5-7.6); V = 79% (76-81%)

Body plump assuming almost straight position when killed by gradual heat (Fig. 3,F); head end broadly obtuse, tail end long-conical, terminus obtuse. Cuticle coarsely annulated, annules often unevenly joined in lateral fields. This uneven annulation beginning anteriorly near head end and extending posteriorly well onto tail. Inner surface of cuticle infolded forming alter-

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Fig. 1.—*Hemicycliophora longicaudata* Loos, 1948, A-F: A, Female head, spear, and esophagus; B, Face view of head showing amphids and lips; C, Uterus showing shape and spherical swelling apparently containing sperm; D, Female posterior end showing vulva and shape of tail; E, Male anterior end showing head and esophageal region; F, Male tail and spicule region, showing shape of spicules, bursa, and general shape of tail. (After Loos, 1948). *Hemicycliophora aquaticum* (Micoletzky, 1913) Loos, 1948, G-H: G, Female; H, Anterior end of female, lateral view. (After Micoletzky, 1914). *Hemicycliophora typica* de man, 1921, I-J: I, Anterior end of larva; J, Posterior end of gravid female. (After Micoletzky, 1925).

nating rings with outer surface as seen in dorsal and ventral profile outline (Fig. 3,E). In lateral fields these infoldings forming characteristic subcircular markings beneath junctions of outer annulation (Fig. 3,D,E). Subcircular markings beginning at 4th or 5th annule (Fig. 3,D), continuing distinctly to region of metacorpus, there appearing less distinct gradually down to region of excretory pore where they may fade out entirely. Width of annules variable, about 3.5 μ at region of posterior bulb then increasing to about 4.3 μ to anal region then decreasing gradually to 2.3 μ and less to terminus. Total number of annules averaging 275 (260-284). Body of adult female almost always observed carrying cast-off cuticle of last laval molt. Molted cuticle attached to body at head and vulva.

Anterior end without setae or papillae. A sclerotized, hollow, cylindrical structure extending beyond lip region in profile view serving as stylet guide, bordered posteriorly by 3 heavily-sclerotized cheilorhabdions. Cheilorhabdions rounded, tapering anteriorly, about 5.1 μ long and 3.4 μ wide (Fig. 3,C). Lumen between cheilorhabdions about 1.8 μ. Extremely slight lateral indentations possibly representing amphid apertures observed slightly below anterior end of hollow cylinder (Fig. 3,C). Amphidial ducts leading from these indentations, however, not observed. Face view of head showing central, sclerotized, hollow structure somewhat rectangular in shape, measuring 7.8 μ in length and 4.6 μ at the widest point. Crescentic slits situated laterally on each side of central cylinder serving as points of attachment for retained molted cuticle (Fig. 3,A). In region anterior to cephalic base plate 6 liplike structures, 2 small, circular, and situated laterally to crescentic slits, 2 larger, somewhat elliptical, situated subventrally, and 2 situated subdorsally (Fig. 3,B).

Slender buccal stylet always curved dorsally measuring 82 μ (77.4-86.9 μ) in length, representing a little less than 1/13th of total body length. Stylet extending through 22 annules composed of 2 portions, a slender curved anterior portion of 67 μ length forming delicate lobes where it joins the posterior, heavily knobbed portion. Posterior portion 15 μ long, more heavily cuticularized than anterior portion. Width of rounded knobs on stylet 4.3 μ (3.6-4.9 μ). Orifice of dorsal esophageal gland about 11 μ behind stylet on convoluted esophageal canal; latter 44.7 μ (38-50 μ) long to valvular apparatus of metacorpus. Lumen of this canal about 1 μ in width. Strongly muscular metacorpus 21 μ wide equipped with heavily sclerotized valvular apparatus 13.5 μ long and 2.2 μ thick. Subventral esophageal glands opening into esophageal lumen directly posterior to valvular apparatus. Esophagus narrowing to form short isthmus behind metacorpus, isthmus overlapped by somewhat inconspicuous nerve ring then expanding to form pyriform, pos-

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Fig. 2.—*Hemicycliophora parvana*. AA—Drawing of adult female in a typical position: ch, cheilorhabdion; pr msc, protractor muscle; amp dsl oe gl, ampulla of the dorsal esophageal gland; amp subv oe gl, ampulla of the subventral esophageal gland; nrv r, nerve ring; p es md cut, excretory pore on molted cuticle; p ex, excretory pore; grn int, intestinal granule; ov cp cl, cap cell of ovary; an, anus; an md cut, anus on molted cuticle. A—Face View. B—Optical cross section anterior to cephalic base plate. C—Profile view of head: amph ap ?, amphid aperture ?; ch, cheilorhadbion. D—Lateral view showing anterior end of lateral field. E—View of annulation and lateral field in midregion of body (nematode stained with acid carmine). F—Characteristic shapes of nematodes killed by gradual heat. G—Ventral view of vulva. H—Lateral view of annulation at region of vulva. I—Ventral view of anus.

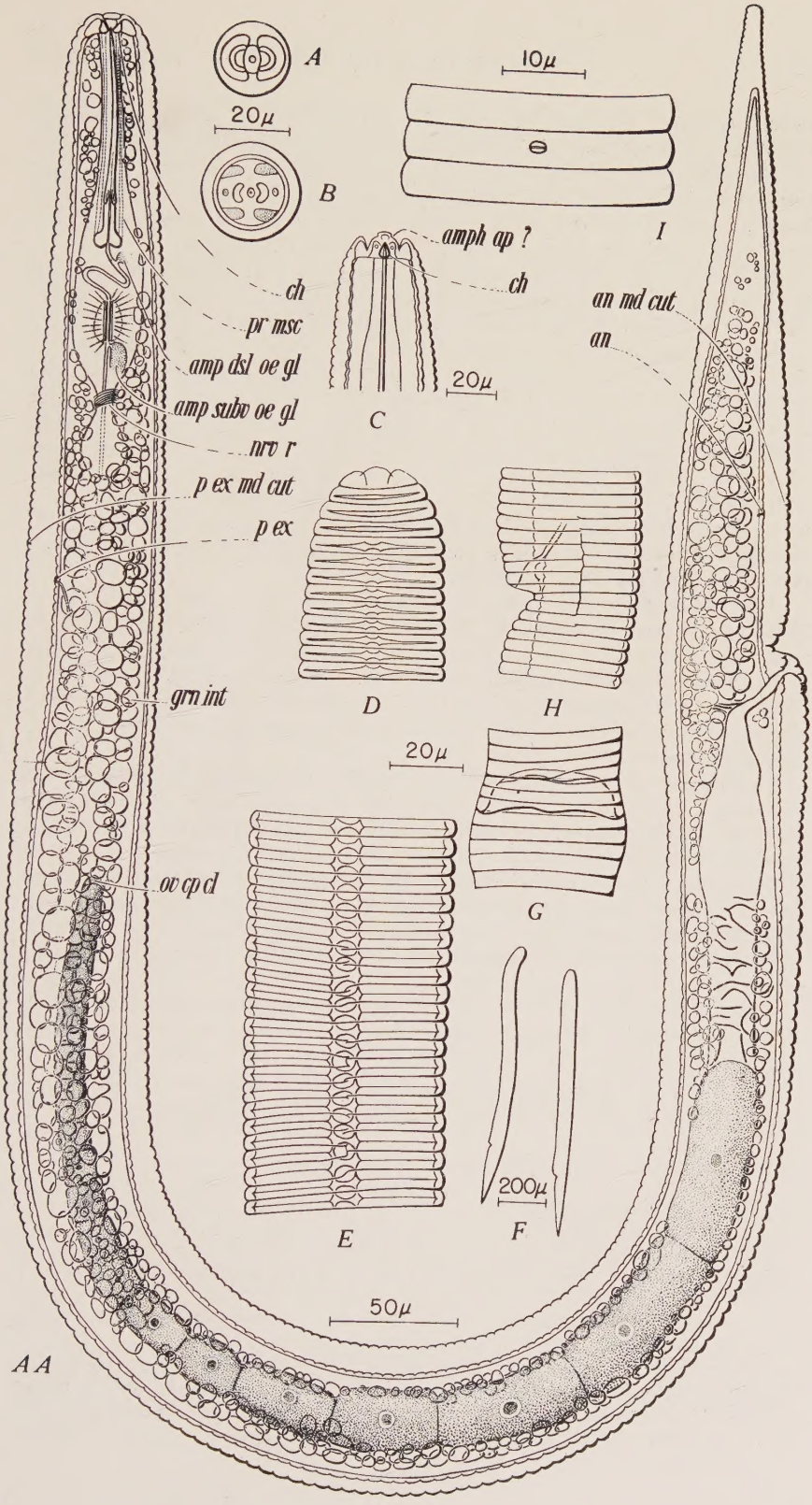
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Fig. 2

teriorly-biclefted terminal bulb of 13.8 μ (13.4-14.3 μ) width. Esophagointestinal valve not observed. Entire esophagus extending through 42 annules.

Excretory pore situated about 12-13 annules behind esophagus. Excretory pore on retained molted cuticle about 6 annules anterior to same structure on body proper. Hemizonid which Goodey (1951) claims is found on *Hemicycliophora typica* de Man, 1921 not observed on *H. parvana.*

In none of the numerous specimens examined were distinct outlines of the intestine observed. Large numbers of reserve globules scattered throughout body and especially in anterior intestinal region (Fig. 3,AA).

Female reproductive organ monodelphic and prodelphic with anterior portion situated well below base of esophagus, usually outstretched but also reflexed in some individuals; length about 47% of body length. Ovary beginning with apical cap cell followed by either single or double row of öocytes, developing in tandem to eggs. Eggs observed in uteri of specimens measuring 52-56 μ by 22-25 μ. Conspicuous vulva, at about 215th annule from anterior end, situated in forward diagonal position in line with heavily cuticularized walls of vagina to which retained molted cuticle is attached (Fig. 3,AA,H). Ventral view of vulva exhibiting pouch-like outline (Fig. 3,G). Body sharply contracted at vulva (Fig. 3,AA,H).

Obscure anus on 16th (14th-18th) annule from vulva, about 47th (43rd-55th) annule from terminus. In ventral view appearing ellipsoidal in shape, measuring about 2.8 μ by 2.3 μ with extremely faint slit bisecting it (Fig. 3, I). Anus on retained molted cuticle usually about 1 annule posterior to body anus. Tail elongated-conical, terminus rounded. Annulation becoming almost indistinct near terminus. Phasmids and caudal papillae not observed.

Male unknown.

Diagnosis: *Hemicycliophora* most closely resembling *H. thienemanni* (Schneider, 1925) Loos, 1949 but differing in greater body width of 54 μ (39 μ for *H. thienemanni*), shorter esophagus of 161 μ (186 μ for *H. thienemanni*), and much longer tail of 159 μ (60 μ for *H. thienemanni*). Further distinguished by characteristic subcircular infoldings of inner cuticular surface at lateral fields. Buccal stylet less than 1/13th of total body length (1/10th of body length for *H. thienemanni*). Anus obscure.

Type Locality: Soil from cultivated field, possibly on which celery was grown, near Sanford, Florida, U.S.A.

Type Host: This species was pathogenic to and reproduced on celery, *Apium graveolens* L. in greenhouse tests.

Hemicycliophora typica de Man, 1921
Synonym—*Procriconema membranifera* Micoletzky, 1925

Fig. 1, I-J; Fig. 3, A-I

Danish specimens (Micholetzky, 1925) 4 ♀: 0.84 mm. (0.70-0.92 mm.); a = 18.5 (16.4-20.6); b = 5.65 (5.0-6.1); c = ?; V = 80.5% (80-82%)
Dutch specimen (de Man, 1921) 1 ♂: 0.68 mm.; a = 30; b = ?; c = 6.3
Ceylonese specimens (Loos, 1948) 4 ♀ 0.68-0.72 mm.; a = 18-20, b = 5.5-5.7; c = ?; V = 83-85%
6 ♂: 0.47-0.65 mm.; a = 31-34; b = ?; c = 6.4-8.0; T = 22%

Female: Body plump, tapering sharply to terminus forming dorsally convex-conoid tail. Cuticle bearing about 200 coarse annules, of which spear extending through 23 (21-24), esophagus extending through 43 (40-45), and region between vulva and terminus extending through 51 (47-56). Width

of annules about 5 μ at middle of body, less toward ends of body. Lateral field appearing as three longitudinal lines crossed by transverse striae thus making 2 rows of rectangles of 1/3-2/5ths the body width. Lateral fields beginning near posterior end of stylet, ending on tail. Five sublateral longitudinal lines, visible in profile view, also present. Molted larval cuticle retained by adult.

Head not set off, without setae or papillae. Cuticle indented at oral opening forming a hollow, sclerotized cylinder which apparently functions as stylet guide. Stylet slender, of 63 μ length representing 1/9-1/10th of total length, with simple knobs at posterior end.

Esophageal canal between base of stylet and valvular apparatus of median bulb convoluted when stylet is retracted. Median bulb of 2/5ths the corresponding body width and containing elliptical sclerotized valves. Isthmus constricted, overlapped by nerve ring. Posterior bulb of 1/3rd the corresponding body diameter. Excretory pore not observed. Intestine vacuolate.

Gonads prodelphic and monodelphic, in outstretched position, occasionally laying in a spiral. In Danish specimens ovary beginning midway on posterior esophageal bulb, in Ceylonese specimens beginning well below bulb. Uterus extending forward 2 body widths. Two eggs seen in uteri of Danish specimens measuring 76-82 μ by 30-32 μ, in Ceylonese specimens measuring 60 μ by 21 μ. Vulva and vagina conspicuously sclerotized.

Rectum and anus not observed.

MALE: Body shorter and narrower than female, tapering somewhat at anterior end and markedly at posterior end to form filiform tail. Cuticle not as coarsely annulated as in female, molted larval cuticle not retained by adult. Lateral field on Ceylonese specimens similar to that on female. The five additional sublateral longitudinal lines present in female lateral field not observed.

Head obtuse, slightly set off, without setae or papillae. Mouth aperture and stylet not observed. Lips completely amalgamated in Ceylonese specimens. An organ of ovoid form present on each side of anterior end.

Esophagus indistinct. Nerve ring visible in some Ceylonese specimens. Esophago-intestinal junction indistinct. Intestine vacuolate. Excretory pore about 90-112 μ from anterior end in Ceylonese specimens and 132 μ from anterior end in Dutch specimens.

Spicules 2, large, sickle-shaped almost semi-circular with recurved tips in Ceylonese specimens, spicule tips not recurved in Dutch specimens. Length of spicules in latter about 43 μ. Gubernaculum in Ceylonese specimens, short and simple, bursa well developed with serrate edge and transverse striae. Bursa without papillae or ribs. Tail measuring 71-96 μ in Ceylonese specimens and 108 μ in Dutch specimens.

DIAGNOSIS: *Hemicycliophora* most closely related to *H. thienemanni* and *H. parvana* but differing in the presence of a lateral field of 2 longitudinal rows of rectangular markings and in the dorsally convex-conoid shape of the female tail (*H. thienemanni* without lateral fields and with short filliform tail; *H. parvana* with lateral field of single longitudinal row of circular, subcuticular infoldings and with elongate-conical tail). Males with characteristic semi-circular spicules.

TYPE LOCALITY: Dutch specimens—in soil of the Municipal Park at Bergen op Zoom, Holland; Danish specimens—soil around Carex roots on banks of Tjustrupsee, Denmark; Ceylonese specimens—in jungle and patna soils, Ceylon.

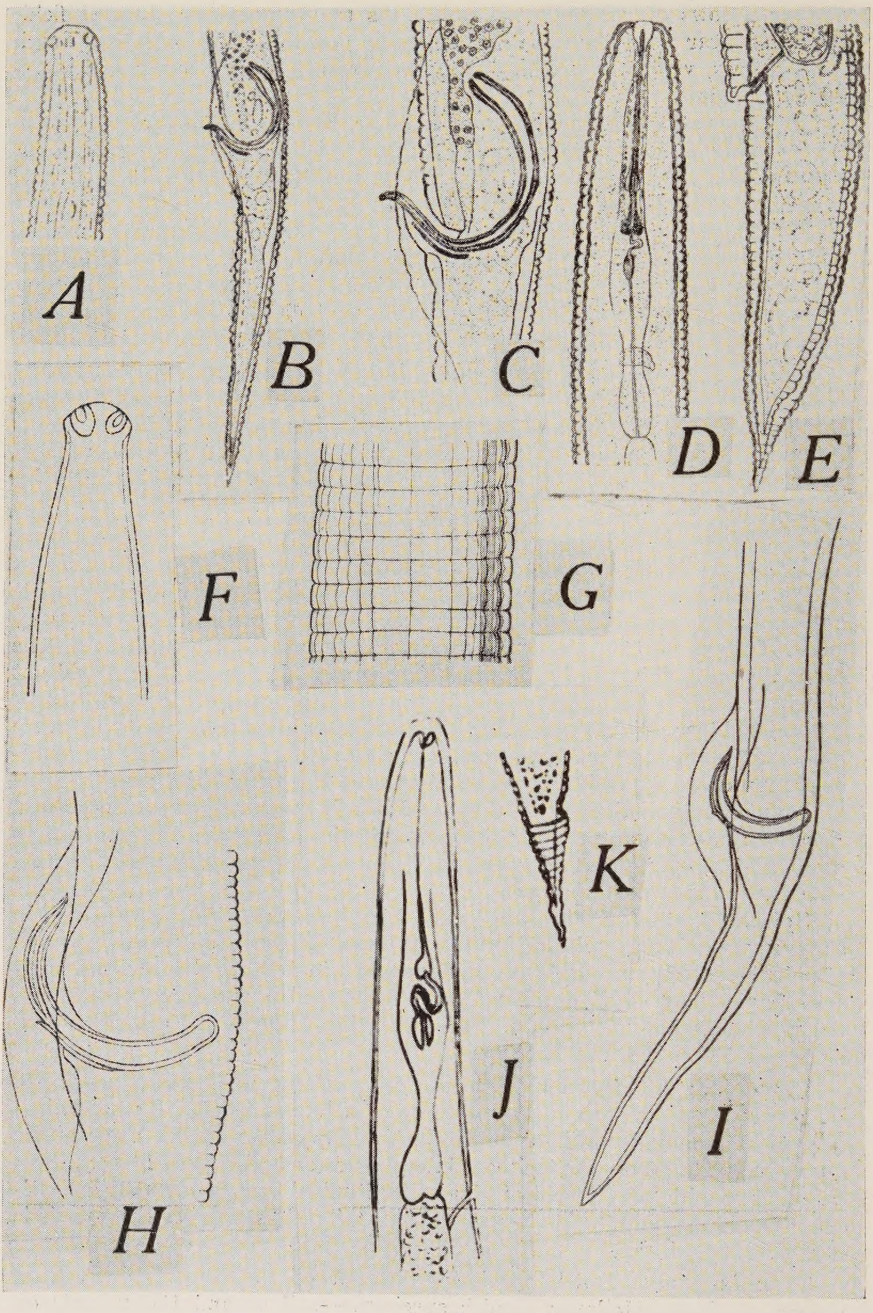

Fig. 3

Hemicycliophore thienemanni (Schneider, 1925) Loos, 1948
Synonyms—*Hoplolaimus thienemanni* Schneider, 1925;
Procriconema thienemanni Micoletzky, 1925

Fig. 3, J-K

1 ♀ : 1.08 mm.; a = 27.7; b = 5.8; c= 18.0; V = 81%

Body slender, anterior end rounded without lips, papillae, or setae. Body diminishes to 1/13th its former width behind vulva. Tail characteristically constricted close behind anus, short and filliform with pointed terminus. Cuticle distinctly annulated with over 250 annules of 3-4 μ width.

Vestibule similar to that of *H. aquaticum* containing 3 sclerotized pieces 7.5 μ long and 1.5 μ thick, the lumen between them 3 μ wide. Buccal stylet equivalent to 1/10th the body length with distinct lumen and pronounced knobs of 9 μ width; stylet slightly curved dorsally. Esophageal lumen convoluted behind stylet forming a loop of 15 μ length (without measuring curvature of folded portions), opening into muscular median bulb, of 21 μ width, equipped with 3 chitinized pieces. Posterior to median bulb esophagus constricting to form isthmus then widening once again to form non-muscular posterior bulb of 15 μ width.

Distinct excretory pore situated at junction of esophagus and intestine. Intestine containing numerous fat globules through which structure of gonads is concealed. Gonads probably monodelphic and prodelphic. Vulva broad and conspicuous, extending forward considerably. Caudal glands absent.

Males not observed.

DIAGNOSIS: *Hemicycliophora* most closely related to *H. parvana* but differentiating itself by the absence of a lateral field, shorter buccal stylet of 1/10th the body length (1/13th the body length for *H. parvana*), and much shorter tail of 60 μ (159 μ for *H. parvana*).

TYPE LOCALITY: Moist soil, Alfsburg Island, Lake Plöner, East Holstein, Germany.

Hemicycliophora micoletzkyi (Goffart, 1948) Goffart 1952
Synonym—*Procriconema micoletzkyi* Goffart, 1948

Fig. 4, A-B

1 ♀ : 1.24 mm.; a = 24; b = 7.3; c = 8.2; V = 80%

Anterior end tapering. Cuticle distinctly annulated with about 400 unornamented annules of 3 μ width. Buccal stylet extending through 44 annules; tail extending through 50 annules.

Anterior end without lips, papillae, or setae. Vestibule containing 3 chitinized pieces, 7.5 μ long and 1.6 μ thick. Buccal stylet 132 μ long, representing 1/9th of body length, equipped with basal knobs without forward pointing processes.

Fig. 3.—*Hemicycliophora typica* de Man, 1921, A-I: A, Male head; B, Male tail and spicule area; C, Spicule area showing sickle-shaped spicules and serrated bursa; D, Female head, spear, and esophagus; E, Female, posterior part, showing vulva, shape of tail, and larval cuticle forming a sheath over the body. (After Loos, 1948). F, Cephalic region of male. (After de Man, 1921). G, Mid-body of female with the cuticular structure slightly schematicized. The central three longitudinal lines represent the actual lateral field. Only three of the five sublateral longitudinal lines are represented dorsally (right in the figure). (After Micoletzky, 1925). H, Bursa and genital armature of male. I, Posterior end of male. (After de Man, 1921). *Hemicycliophora thienemanni* (Schneider, 1925) Loos, 1948, J-K: J, Anterior end of female; K, Female tail. (After Schneider, 1925).

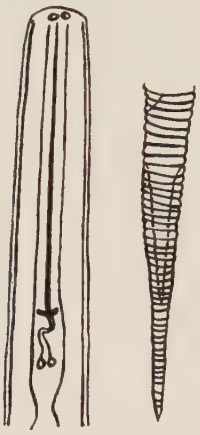

Fig. 4—*Hemicycliophora micoletzkyi* (Goffart, 1948) Goffart, 1952, A-B: A, Anterior end (Annulations omitted); B, Female tail. (After Goffart, 1952).

Esophagus consisting of muscular median bulb and nonmuscular posterior bulb. Female gonads prodelphic and monodelphic, 142 μ long. Tail constricted behind anus and then uniformly attenuated to acuminate terminus.

Diagnosis: *Hemicycliophora* resembling *H. thienemanni* but having a longer tail of 150 μ (60 μ for *H. thienemanni*).

Type Locality: Subterranean water, Aschaffenburg, Germany.

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Sphaeronema californicum, nov. gen. nov. spec., (Criconematidae: Sphaeronematinae, nov. subfam.) an endoparasite of the roots of certain plants

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A soil sample collected by the junior author on April 22, 1950 from a stream bank near Inverness, California contained several male nematodes which appeared to belong in the genus *Paratylenchus*. A thorough search of the original sample and an additional soil sample from the same locality failed to provide females for more positive identification. Root material was later secured from the principal plant, *Umbellularia californica* Nutt., growing in the immediate locality. These roots were washed clean and female nematodes were found inside the roots when the roots were dissected under a microscope. Many more females were readily found by briskly rubbing the roots together in a beaker of water and searching the sediment. The most effective means of collecting large numbers of all stages of this nematode was by staining the roots with acid fuchsin in boiling lactophenol as described by Goodey (1937). The roots could then be easily torn apart in clear lactophenol and the nematodes mounted in lactophenol or transferred directly to dehydrated glycerine for mounting. It was found even in the presence of a high population of this nematode that relatively few specimens could be secured by screening the soil. However, large numbers of males and larvae were readily collected by washing infected roots free of soil and storing in a beaker of clear water for several days. One sample of soil containing roots was held in a refrigerator at approximately 5° C. for over a year after which time numerous live specimens could be obtained from the roots in this manner.

Although the roots appeared to be severely damaged by the high population of nematodes found attacking them, the tree did not show any above ground symptoms which would suggest a weakening of the plant. The nematodes occurred more or less in colonies in the small lateral and feeder roots and the areas thus heavily infected showed a general breakdown of the cortex and bark. The adult females secret a gelatinous matrix which usually contains many eggs, larvae and males. Considerable debris usually adhered to the matrix giving it a characteristic dirty appearance.

Further attempts were made to collect this species in or about the roots of *Umbellularia californicum* in at least five widely separated areas in California

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without success. However, a soil and root sample of an *Arctostaphylos* sp. collected by Dr. J. W. MacSwain of the University of California in the Sierra Nevada Mountains of California showed the roots of this plant to be attacked by this same species of nematode. This suggests that *Sphaeronema californicum* is probably widely distributed in California and may occur on several different species of plants.

Subfamily Sphaeronematinae, new subfamily

Criconematidae. Female body sub-spherical, cuticle thick, marked by a well-defined reticulate pattern. Lips of vulva protrude prominently, subterminal in position. Males degenerate, bursa absent.

Type genus: *Sphaeronema* n. g.

Diagnosis: Sphaeronematinae are most closely related to the subfamily Paratylenchinae. This relationship is shown most markedly in the shape and structure of the male. The small cuticular flap found laterally near the vulva and the well-defined isthmus are also present in Paratylenchinae. In addition the enlarged female shape is only found in the genus *Cacopaurus* of this family. Sphaeronematinae are distinguished from Paratylenchinae by the sub-spherical shape of the female, by the reticulate pattern of the female cuticle, by the protruding lips of the vulva and by their endoparasitic habit of feeding.

Genus *Sphaeronema* new genus

Sphaeronematinae: Larva provided with a strongly developed spear. Sclerotization of head with hexaradiate symmetry. Female sub-spherical, spear well developed, one or two very obscure annules present near lip region. Esophagus very strongly developed. Ovary single, uterus unusually large with thick muscular walls. Males slender, active, spear lacking, esophagus degenerate, bursa absent, spicule sheath present. Testis one.

Type species: *Sphaeronema californicum* n. sp.

Sphaeronema californicum new species

♀ : L. = 0.134-0.209 mm.; a = ?; b = ?; c = ?; V = subterminal.
♂ : L. = 0.395-0.470 mm.; a = 33.2-44.8; b = ?; c = 12.0-14.8; T = 20.3-29.8%; gub = 3-4.5 μ; spicule = 19-21 μ.

Larva: (Fig. 1,A-C). L = 0.390-0.470 mm.; a = 25-31; b = 3.3-4.4; c = 10.7-11.5. Body slender, cylindrical. Annulation of body fine and obscure. Lateral field not marked by definite lines. Lip region continuous with neck. Sclerotization of lips hexaradiate. Spear 14.4-16.7 μ, prorhabdion 53-57% of total length. Knobs of spear rounded swellings. Esophagus long, slender with well-defined isthmus. Excretory pore slightly anterior to nerve ring. Anus very obscure. Tail conoid, arcuate with bluntly rounded terminus, occasionally more sharply conoid than illustrated.

Female: (Fig. 1, G-I). Body sub-spherical with protruding neck which frequently assumes elaborate shapes due to conformity with the host-plant cellular structure. Cuticle strongly developed, up to 9 μ thick, marked by conspicuous reticulate pattern. One or two very obscure annules near lip

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Fig. 1.—*Sphaeronema californicum*. A—Neck region of larva, × 650; B—Face view of larva, × 1000; C—Tail of larva, × 500; D—Neck region of male, × 1000; E—Male tail, × 1000; F—Male, × 400; G—Female head, × 1000; H—Criss section of median bulb of female, × 330; I—Female, × 330.

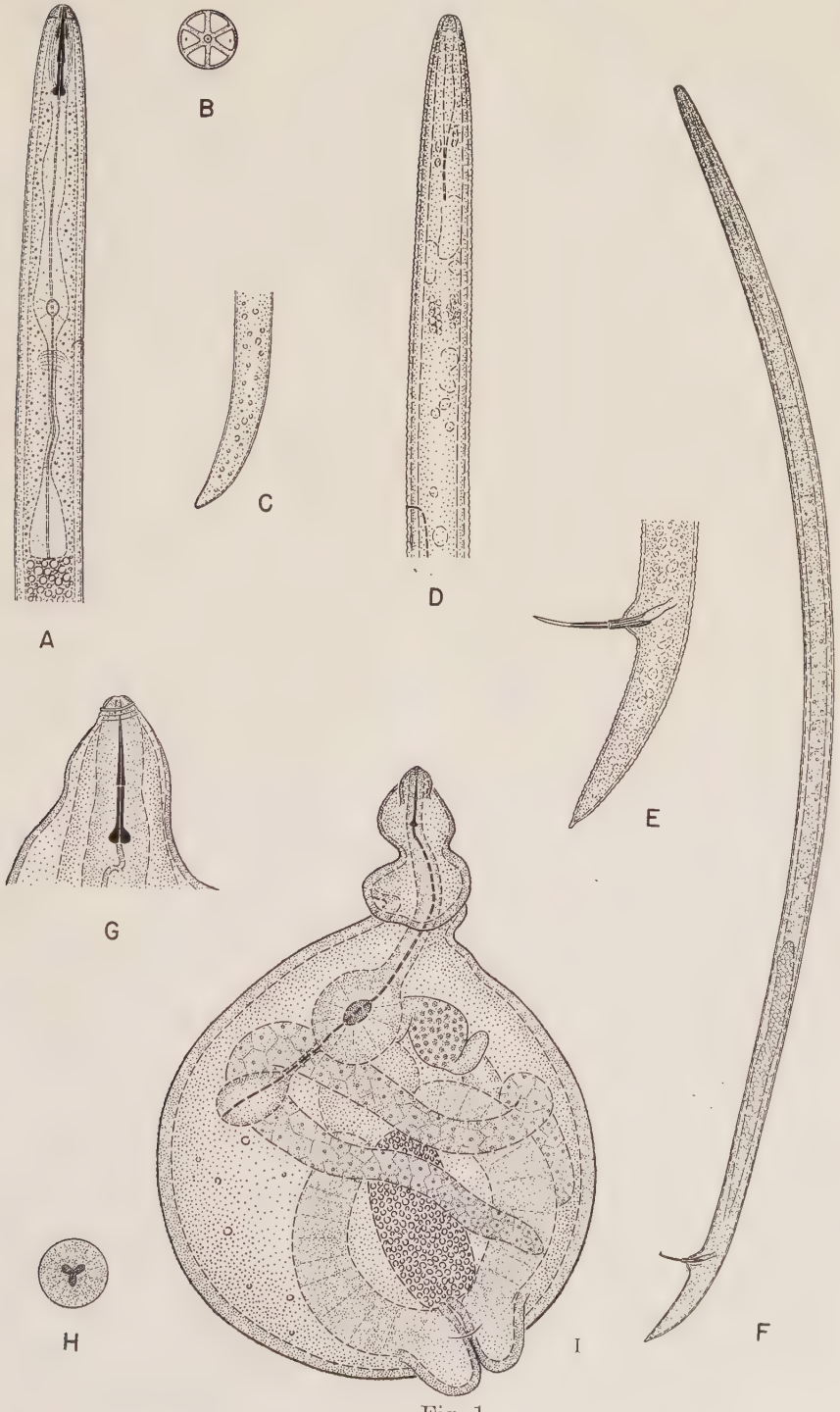

Fig. 1

region. Lateral field not marked by definite lines. Reticulate pattern assuming vague cross lines near and on lips of vulva.

Sclerotization of head very delicate, obscure in face view. Spear 14-20 μ long, prorhabdion 51-60% of total length. Knobs of spear simple swellings, directed slightly posteriorly. Lip region set off by a very faint annule, the anterior surface of which bears minute smooth rounded lips. Esophagus well developed. Corpus elongate, cylindrical. Median bulb rounded with prominent tri-radiate sclerotized valve. Isthmus slender with well-set-off posterior bulb. Junction of esophagus and intestine obscure. Lumen of esophagus approximately 1 μ wide, heavily sclerotized. Excretory pore present on neck region about the level of median bulb. Dorsal gland orifice approximately 4-5 μ posterior to spear. Ovary single, leading to a greatly developed uterus with unusually thick, muscular walls. Vulva subterminal with prominent, protruding lips. Small somewhat indefinite cuticular flap present laterally near vulva lips. Anus and phasmids not observed.

Immature female nematodes prior to last molt pear-shaped without protruding vulva, reticulate pattern of cuticle lacking.

Male: (Fig. 1, D-F). Lip region smooth, set off by slight constriction. Sclerotization delicate, obscure in face view. Cuticle marked by narrow transverse annules. Lateral field not marked by definite lines. Esophagus degenerate, spear absent. Excretory pore—0.066-0.099 mm. from anterior end. Hemizonid small, located on third annule posterior to excretory pore. The position of the hemizonid differs from the examples reported by Goodey (1951), who described it as anterior to the excretory pore in all cases observed by him. Testis 20.3-29.8% of length. Spicules 19-21μ long, slender, slightly curved ventrally. Bursa absent. Gubernaculum 3-4.5 μ long, simple and slightly curved. Spicule sheath conspicuous. Cuticle bulges characteristically in region of cloacal opening. Phasmids not seen. Tail conoid with rounded terminus, curved slightly ventrally.

Type host: Roots of California laurel, *Umbellularia californica* Nutt.

Type locality: On shore of Tomales Bay, ¼ mile northeast of Inverness, Marin County, California; elevation near sea level.

Host plants: Also collected in roots of *Arctostaphylos* sp. near Pyramid Ranger Station, El Dorado County, Calif.; elevation 5,500 ft.

Type specimens: Holotype—female; allotype—male; 232 paratypes deposited in the University of California Collection, Berkeley, Calif.

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Report of the Brayton H. Ransom Memorial Trust Fund

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Eloise B. Cram,
Secretary-Treasurer

Anthelmintic Studies with 6-Tertiary-butyl-m-cresol in Dogs

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In conducting preliminary tests with a large variety of compounds for their anthelmintic value, the writer found several chemicals which seemed promising as therapeutic agents for the removal of helminths from dogs. One of these, 6-tertiary-butyl-m-cresol, because of the findings reported by the writer (Am. J. Vet. Res., 11:58-69, 1950), has been investigated further to define more sharply the value of this compound as a vermifuge for dogs. The results of these studies form the subject of this paper.

MATERIAL AND METHODS

6-t-butyl-m-cresol is a straw colored liquid with a cresolic odor. It has a moderately irritating and mild anesthetic action when placed on the oral mucosa. Its boiling point is 244°C at 760 mm., the specific gravity is 0.922 at 80°C, and it is insoluble in water.

The drug was administered in an unaltered state, in combination with mineral oil, castor oil, and kaolin, in hard gelatin capsules at various dose levels after a fasting period from 6 to 36 hours; however, the majority of dogs were fasted from 18 to 24 hours. Feeding was resumed 2 to 6 hours after treatment.

The 47 dogs used as test animals were of mixed breeds and varied in age from two months to approximately a year. They were placed in individual cages and the stools collected for two or more days before treatment to determine whether or not helminths were being eliminated spontaneously. The feces were also examined prior to treatment to determine the kind of worms present in the dogs. Following administration of the drug, stools were collected for at least three days. The feces collected after treatment were washed through various-sized screens to recover all parasites that may have been evacuated. The dogs were autopsied from 3 to 14 days after receiving the compound. The entire gastrointestinal tract was examined for parasites by washing the contents through screens. All the organs from both body cavities were carefully examined for evidence of gross lesions. Sections were prepared from the stomach, intestine, liver, and kidneys of a large number of dogs for histopathologic study and in some of the animals additional organs were studied microscopically.

RESULTS

Series 1. The pure chemical was administered to 26 dogs in doses varying from 0.05 cc. to 0.3 cc. per pound of body weight. Each of the 26 dogs harbored one or more species of helminths at the time of treatment. This group of dogs (19 positives) harbored a total of 151 ascarids. Of this number (151), all but five were expelled (96.7%) following treatment. The five retained ascarids were found in two dogs. One of these dogs, fed six hours before receiving the drug, failed to pass any of its four worms; the other,

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which retained one of seven ascarids, was destroyed 24 hours after receiving the compound. The above observations suggest the desirability of withholding food for a longer period than six hours since all the other dogs, except one, when fasted for 18 hours or longer, expelled 100 per cent of the ascarids at the time of treatment.

The effect of the unaltered compound on *A. caninum* harbored by nine dogs seemed to be variable in that 3 dogs harboring from one to four each failed to pass any of these worms following the administration of 0.1 cc. per pound of body weight in a single dose. A fourth dog, harboring 10 *A. caninum,* also failed to evacuate these helminths after receiving a single dose of 0.3 cc. per pound of body weight. In experiments where the dose was divided into two parts and given on consecutive days the dogs evacuated from 10 to 100 per cent of the *A. caninum.* The three dogs which received 0.15 cc. per pound of body weight, divided into two parts and given on consecutive days, expelled 51 per cent (18) of 35, 69 per cent (22) of 32, and 10 per cent (1) of 10 *A. caninum* respectively or a total of 53 per cent (41) of the 77 hookworms present in the three dogs under discussion. In another experiment, two dogs, which were harboring the common hookworm, received 0.3 cc. per pound of body weight divided into two parts and given on consecutive days, expelled 96 per cent (205) of 213, and 100 per cent (7) respectively or a total of 96.4 per cent (212) of the 220 *A. caninum* present at the time of treatment.

Two dogs harboring *Uncinaria stenocephala* received 0.1 cc. per pound of body weight. One of the dogs expelled 100 per cent (21) and the other 95 per cent (63) of 66 *Uncinaria* or a total of 96 per cent of the 87 *Uncinaria* present in both dogs at the time of treatment. These two dogs were also infected with seven *A. caninum*, none of which were evacuated following treatment.

The drug when given in its pure state varied in its efficiency as an expeller of cestodes from dogs. Seven dogs used in these experiments harbored 94 tapeworms. Four of these dogs were infected with *Taenia*, two had both *Taenia* and *Dipylidium* and the remaining animal carried *Dipylidium* only. The number of *Taenia* present in the dogs varied from one to forty per animal. The dogs infected with *Dipylidium* harbored five in one, 12 in another, and in the case of the third only segments were found following treatment. The six dogs harboring a total of 77 *Taenia* expelled 26 per cent (19) following treatment. One of the dogs, receiving 0.1 cc. per pound of body weight, expelled 100 per cent (3) of its *Taenia*; another dog expelled 15 *Taenia* (100 per cent) following the administration of 0.3 cc. per pound of body weight, divided into two doses and given on consecutive days. In the other cases, the drug seemed to have very little effect on *Taenia.* Of the dogs harboring *Dipylidium caninum* one failed to expel this cestode (12) after receiving a 0.1 cc. dose of the medicament, while another animal expelled 100 per cent (5) of the *Dipylidium* when given 0.3 cc. per pound of body weight of the drug divided into two doses and administered on consecutive days. A third dog passed many *Dipylidium* segments following treatment, but in this case no heads were found in the feces following treatment or at necropsy. Thus, the drug given in a dose of 0.2 cc. per pound of body weight may have caused the expulsion of the heads also.

Series 2. Eight dogs were each given 0.1 cc. of 6-t-butyl-m-cresol per pound of body weight in combination with an equal (4 dogs) or double (4 dogs) quantity of mineral oil. All of these animals harbored ascarids, 11 being the largest number present in any one dog. The combination adminis-

tered to these animals removed 100 per cent (39) of the ascarids present. Two of the dogs in this series harbored a total of 8 *A. caninum.* The dog harboring seven of these parasites expelled 71 per cent (5), while the other dog, which vomited two hours after receiving the drug, failed to eliminate its single hookworm.

Four of the dogs in this group harbored *Taenia,* one of these expelled two of its three cestodes. A second dog infected with 138 *Taenia* expelled only two. This animal vomited ten minutes after receiving the medicament. The mate of the latter animal failed to eliminate the single *Taenia* present. The fourth dog evacuated 100 per cent (15) of the *Taenia* within two hours after receiving the drug. In the latter, food was withheld for six hours after receiving treatment. Vomiting did not occur in this animal.

Series 3. Each of four dogs received 0.1 cc. of 6-t-butyl-m-cresol per pound of body weight, together with an equal quantity of castor oil in the same capsule. Three of these dogs harbored a total of 32 ascarids, all of which were evacuated following treatment. In this group three dogs were infested with *A. caninum*; one eliminated 137 (86 per cent) of the 158 *Ancylostoma* present when given the compound. A second animal evacuated only one of 13 hookworms present at time of treatment. Both dogs defecated within one hour after medication. The dog harboring the 158 hookworms eliminated 41 of them in the stools evacuated within the hour following treatment. The remaining one of the three dogs, infected with 31 *A. caninum,* failed to evacuate its hook worms following treatment. A single *Taenia* in one of the dogs of this series was not expelled.

Series 4. The nine animals in this series received 6-t-butyl-m-cresol in doses varying from 0.09 to 0.2 cc. per pound of body weight together with kaolin in the same capsule.

Seven of these dogs harbored a total of 44 ascarids, 95 per cent (42) of which were eliminated following treatment. The dog retaining its two ascarids vomited within an hour following the administration of the drug. Two dogs in this series harbored hookworms. One of these, harboring 129 *Uncinaria,* evacuated only 22 per cent (29) of its worms following treatment. The other dog, which was given 0.2 cc. per pound of body weight, failed to discharge its six hookworms (species not determined). Another point of interest is that two dogs infected with a large number of *Dipylidium* failed to eliminate any of these parasites following doses up to 0.13 cc. per pound of body weight, while two others, harboring a total of 34 (30 and 4 respectively) *Dipylidium,* evacuated 100 per cent of this species when treated with doses of 0.2 cc. per pound of body weight.

Among the dogs discussed, 13 harbored a total of 485 *Trichuris.* The number of this species varied from 1 to 117 per animal. The compound was administered in doses varying from 0.1 cc. to 0.3 cc. per pound of body weight and in only 2 instances were whipworms expelled following treatment; one dog eliminated 4 of its 12 and the other only one of the 83 *Trichuris* present. Therefore, these results indicate that 6-t-butyl-m-cresol has little value against *Trichuris* in the dog.

TOXICITY. From the data obtained in the experience on dogs with 6-t-butyl-m-cresol it seems apparent that the drug is nontoxic when given, *per os,* in doses up to 0.4 cc. per pound of body weight. The dog given 0.4 cc. per pound of body weight, weighed 20 pounds and received a total of 8.0 cc. of the drug over a period of 6 days. Other dogs received single doses up to 0.3 cc. per pound of body weight without showing clinical evidence of a toxic

reaction. However, the compound did produce some vomiting, either shortly after it was given or after the first feeding, but in no case was the vomiting followed by illness.

The writer inoculated 2 dogs intravenously (cephalic vein) to determine what effect the chemical may have when introduced into the circulation. The doses were 0.083 cc. and 0.033 cc. respectively. Both dogs went into a state of narcosis shortly after receiving the compound. After about thirty minutes the animals reacted to stimuli; one became conscious after 90 minutes, the other an hour later but neither regained complete coordination. One dog showed bloody froth exuding from its nose. Both dogs died within 21 hours after the inoculation.

The necropsy examinations of the dogs receiving the drug *per os* were negative in all instances. The 2 dogs receiving the compound intravaneously showed hemothorax, extreme hemorrhages in the lungs, mediastinum and kidneys.

Histopathologic studies were made on the liver and kidneys of a portion (25) of the dogs treated *per os*. The intestines and stomach of most of these cases were also studied and, in some instances, the pancreas and adrenals likewise received consideration. The dogs from which tissues were taken for histopathologic study were given the drug in doses varying from 0.1 cc to 0.4 cc. per pound of body weight and the animals were permitted to live from 24 hours to 14 days. The result of these studies were all negative save for a few cases where the tips of the villi of the intestine showed a mild hyperemia which was within a normal physiological range. In contrast, the 2 dogs receiving the drug intravaneously showed marked damage in both lungs and kidneys. In the lungs the blood vessels were engorged with blood and a yellowish brown material; the latter was in all probability the compound. The alveoli, bronchi, and interstitial tissue contained much free blood. Many granulocytes, lymphocytes and some macrophages were scattered through the pulmonary tissue. The damage in the kidneys was marked in both dogs. The changes were those of a mild to an extreme degeneration even to the point of death of the tubular epithelium, especially in the convoluted tubules. There were some destructive changes in some of the glomerular tufts. There was much hyperemia in both the cortical and medullary portion of the kidney. There was also evidence of much hemorrhage in the tubules, renal corpuscles, and interstitial tissue contained free blood. The dog receiving the larger dose showed the more pronounced changes in the kidneys.

Conclusions

In the four series of experiments here reported 37 dogs harbored a total of 266 ascarids. Of this number, 259 or 97.3 per cent were expelled following treatment. The 7 ascarids found at necropsy were retained by 3 dogs. One of these animals, fed 6 hours before treatment, retained 4 of its 5 ascarids. Another one, which vomited within an hour after treatment, failed to expel its 2 ascarids. The third dog, sacrificed two hours after treatment, failed to evacuate 1 of the 7 ascarids present at the same time the medicament was administered.

The compound was administered in doses varying from 0.05 cc to 0.3 cc. per pound of body weight. The drug, regardless of the size of the dose, seemed to be highly efficient against ascarids except for the animal fed 6 hours before treatment.

The administration of this chemical was followed by emesis in some dogs

but this reaction did not seem to detract from its efficacy, save for one dog, as an ascaricide.

Another important point is it ability to bring about prompt evacuation as well as expulsion of many of the ascarids within 30 minutes to a few hours. This feature was also noted with reference to the elimination of other parasites from some animals.

In the case of *Ancylostoma caninum* infections in dogs, the effect seemed to be quite variable in that some of the dogs failed to evacuate any of these parasites while in others it expelled up to 100 per cent. The trials which seemed to yield the best results were those where the 0.3 cc. doses (per pound of body weight) were divided equally and given on consecutive days. In these tests, 96.4 per cent of the 220 *A. caninum* were expelled.

The value of the compound against *Uncinaria stenocephala* seemed encouraging when given in the unaltered state since 96 per cent (63) of the 66 *Uncinaria* were expelled although at the same time, this medication failed to expel any of the *Ancylostoma*. However, another dog receiving the compound in combination with kaolin did not respond similarly; only 22 per cent of the worms were expelled following treatment.

The results pertaining to the expulsion of cestodes were variable. Some animals eliminated 100 per cent of both *Taenia* and *Dipylidium* while others eliminated only a small percentage or none of the tapeworms following treatment.

This chemical seemed to have no value as an anthelmintic for *Trichuris*.

There was very little evidence that this drug is toxic when given *per os* in the dosages employed.

On the Morphology of *Criconemoides* Taylor, 1936, with Descriptions of Six New Species (Nematoda: Criconematidae)

DEWEY J. RASKI[1]

There are, at the present time, 21 species of nematodes assigned to the genus *Criconemoides*. Eight of these species have been reported from the United States. Members of the genus are widely distributed and are commonly encountered in collections from cultivated fields as well as in many native habitats. Several species have been reported as parasitic on the roots of plants (Taylor 1936, Chitwood 1949, Steiner 1941, 1949) but experimental evidence is still lacking as to the full extent of damage that can be ascribed to these nematodes. The identification of specimens has been complicated by several species that are closely related to *C. mutabile* Taylor, 1936 or *C. rusticum* (Micoletzky, 1915) Taylor, 1936. The present work was undertaken to further explore the morphology of these nematodes and more firmly establish their relationships.

Taylor (1936) published a complete account of the genus *Criconemoides* up to that time and proposed this generic name for all the species placed in the genus *Criconema* by Micoletzky (1925). Chitwood (1949) redescribed and re-erected *Criconemoides simile* (Cobb, 1918) which was considered to be a synonym of *C. rusticum* by Taylor (1936). In addition, six new species

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have been described including *Criconemoides congolense* (Stekhoven and Teunissen, 1938) Goodey, 1951 and *Criconemoides citri* Steiner, 1949. Rahm (1937) described a new species, *Hoplolaimus sinensis,* which was later transferred to the genus *Criconemoides* by Goodey (1951). However, this species was described with two ovaries and with the vulva at 47% which is not consistent with the other members of the genus *Criconemoides* and cannot belong there. The true position of *sinensis* must therefore remain uncertain until specimens can be obtained for further examination and diagnosis.

Loos (1949) described three new species of *Criconemoides* from Ceylon including the description of males of two of the species. The descriptions, however, show several characters not consistent with other species in the genus *Criconemoides.* The annules are not retrorse and the last larval skin is retained on the adult female as in *Hemicycliophora.* Also the absence of a bursa in the males is different from the small but distinct bursa found on the males described here. On the basis of these differences the species described by Loos are believed to belong to a genus other than *Criconemoides.* Further work on these and related species will be necessary to establish the true position of the species.

The determination of species of *Criconemoides* is based principally on the total number of annules on the body, spear length, shape of tail posterior to the vulva, number of annules between the vulva and the terminus and the characteristics of the annules of the lip region. A strict definition of the lip region is often difficult to establish. The internal sclerotization usually extends through several annules yet only the first one or two have ever been found to be differentiated from subsequent annules. In some cases it is difficult to decide which annules can definitely be distinguished from succeeding body annules. However, most of the above characters are valid if consideration is given the full range of variability within a species. The number of annules between the vulva and terminus, for example, is much more variable in some species than previously reported. In such cases this character can only be used as a specific difference when the ranges do not overlap. Anastomosis of annules on the tail may result in different annule counts on a single specimen, depending on which side of the body the count is made.

One important morphological character not yet fully exploited as a specific difference is the presence or absence of four sub-lateral lobes on the lip region and their variation in size, shape and disposition when present. Stefanski (1916) first illustrated "cuticular protrusions" as he called them in describing *Criconemoides heideri* (Stefanski, 1916) Taylor, 1936. Steiner (1920) referred to the existence of four submedian, rather large papillae in describing *Criconemoides peruense* (Steiner, 1920) Taylor, 1936. Cobb (1924) illustrated a face view of the same species in describing the amphids on the lip region. This face view definitely established the nature of these lobes for the first time. The origin of these sublateral lobes is uncertain. Innervations leading to the lobes can be traced internally and they may represent modifications of papillae. It is also possible the lobes result from the modification of an annule. Whatever their origin, they are valuable taxonomic guides.

Menzel (1917) pointed out the distinctive cuticular pattern on the larval forms of *C. heideri.* This character has since been used by Taylor (1936) and Chitwood (1949) and should be included in taxonomic considerations whenever possible.

Many specimens in the University of California collection have been identified through the use of the key presented by Taylor (1936) and appear closely related to *C. rusticum* or *C. mutabile.* Several species obviously differ-

ent from one another key out to *C. rusticum* and others have characters intermediate between the two species. The problem of distinguishing other species from *rusticum* will eventually require either an arbitrary designation of neotypes and redescription from them in the light of recent work or the collection of type material from Europe and redescriptions made from it. Actually the specimens examined by this author do not seem to fit the characters of *rusticum* especially in regards the head and lip regions. It therefore seemed advisable to accept *rusticum* as described and wait until such time as specimens can be obtained which more closely agree with the original description before redescriptions should be made.

A study of the specimens of *Criconemoides* contained in the University of California collection revealed six new species the descriptions of which follow. Redescriptions of *C. mutabile* and *Criconemoides informe* (Micoletzky, 1921) Taylor, 1936 are presented on the basis of further studies on the morphology of the two species.

Criconemoides xenoplax n. sp.

♀ : 0.404-0.620 mm.; a = 8.3-13.6; b = 3.1-4.8; c = 23.1-55.6; V = 90.2-95.3%.
♂ : 0.530-0.610 mm.; a = 22.5-27.7; b = ? ; c = 12.4-15.3; T = 27.9-35.1%.

LARVA (Fig. 1, M-N). Head and tail bluntly rounded as in female. Sublateral lobes present. Spear length 59-65 μ. Total annules 96-114, marked on posterior edge by fine longitudinal lines.

FEMALE (Fig. 1, A-I, O, T). Oral aperture obscure at surface, internally shows as a narrow slit near base of sclerotization. Conspicuous, elevated, labial disc surrounding oral opening. Amphid apertures obscure appearing as narrow, darkened slits on lateral margins of labial disc. Labial disc expanded near base to include the amphidial pouches. Sclerotization hexaradiate with internal innervations present in four submedian sectors. Lateral sectors bearing elongate, indefinite innervations of amphids. Sublateral lobes conspicuous, placed equidistant about the labial disc and well separated from one another. The lobes project outward and forward sometimes as far as edge of labial disc. In ventral view the ventro-sublateral lobes appear connected. The same is true of the dorso-sublateral lobes but there is no perceptible connection between the sublateral lobes dorso-ventrally. These connections are obscure in face view. First annule variable, usually divided into four labial plates which may be simple, notched or indented. Labial plates may also be reduced in number, rudimentary in size, complicated by anastomosis with second annule or completely lacking. First two annules not retrorse, smaller and narrower than succeeding body annules but not set off, presenting a bluntly rounded outline.

Spear length 71-86 μ. Excretory pore on 25-35th annule from anterior end. Vulva on 6-11th annule from end of body, generally on 7-8th. Anterior flap of vulva variable but usually presents a bilobed appearance. Anastomosis with preceding or succeeding annules often complicates vulva pattern. Ovary extends 40.2-79.0% of body length. Anus located on 4-8th annule from end of body. Terminus a simple rounded or lobed button. Total annules 87-114.

MALE (Fig. 1, J-L, P-S). Details of face view exaggerated slightly for purposes of illustration since they are somewhat obscure. Lip region definitely elevated, no striae present on lips. Sublateral lobes small, placed equidistant about the large labial disc. Innervations of amphids appear to be present but amphid apertures obscure. Hexaradiate sclerotization delicate, extending 4-5 annules posterior to lips, internal innervations present in four submedian sectors.

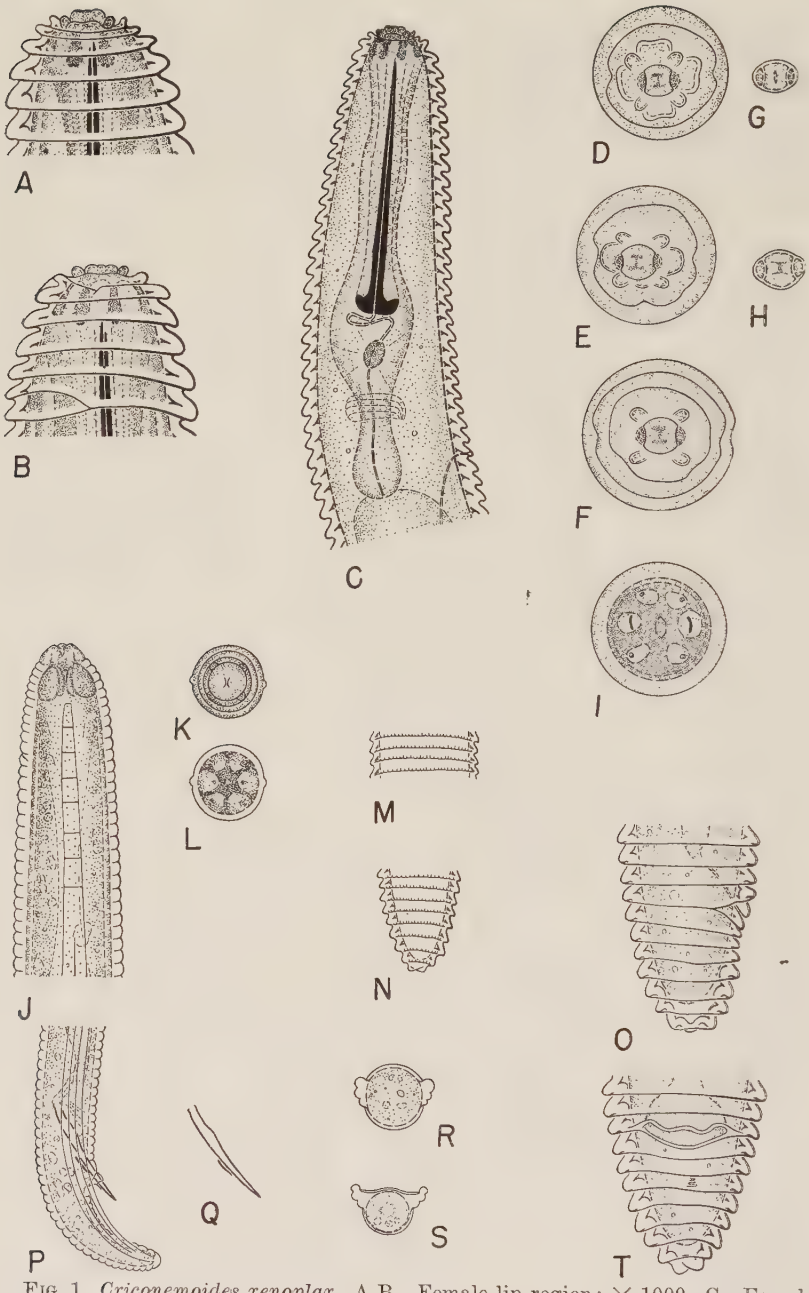

Fig. 1. *Criconemoides xenoplax.* A-B—Female lip region; × 1000. C—Female neck region; × 450. D-F—Female face view; × 1000. G-H—Labial disc of female; × 1000. I—Sclerotized framework of female head; × 1000. J—Anterior end of male; × 1000. K-L—Face view and sclerotized framework of male; × 1000. M-N—Cuticle pattern of larva, midway on body and on tail; × 500. O—Female tail, lateral view; × 500. P—Male tail; × 500. Q—Spicule and gubernaculum of male; × 500. R-S—Cross sections of male tail, slightly anterior (R) and posterior (S) to cloacal opening; × 500. T—Female tail, ventral view; × 500.

Annulation coarse, 1.4-1.5 μ wide near head, 2.8-3.1 μ wide midway. Lateral field marked by four incisures beginning as two at about 6-7th annule from lip region. Faint cross striae present in first part of lateral field. Esophagus indistinct, spear absent. Excretory pore 0.132-0.138 mm. from anterior end of body. Hemizonid almost two annules wide, located 6-7 annules anterior to excretory pore.

Spicules 38-43 μ long, slightly curved. Gubernaculum simple, rod-like, 8-9 μ long. Spicule sheath protrudes conspicuously, bears a short, rod-like process on posterior edge. Tail constricts posterior to spicules and is coarsely annulated to terminus which is bluntly rounded. Bursa small, begins slightly anterior to cloacal opening and extends almost to terminus. Lines of lateral field extend almost to terminus on lateral sides of bursa.

Males rare, known only from type locality.

TYPE SPECIMENS. Holotype—female, Catalogue #1; allotype—male, Catalogue #2; 87 paratypes in Calif. Coll. #201 in University of California collection, Berkeley.

TYPE HABITAT. Soil taken about roots of Thompson seedless grape (*Vitis vinifera* var. *sultanina*) grown on #1613 (*Vitis longii*) rootstock.

TYPE LOCALITY. About 4 miles east of Fresno, Fresno County, Calif.

DISTRIBUTION. This species was also collected from many localities in California in soil about roots of walnut, plum, California laurel (*Umbellularia californica*) and from a stream bank; soil at roots of pine, Idaho Springs, Colorado; soil taken in woods near Beebe Lake, Ithaca, N. Y. and soil from woods near Peconic, Long Island, N. Y.

DIAGNOSIS. *Criconemoides xenoplax* keys to *C. rusticum* according to Taylor (1936) but differs from it in spear length and shape of head and tail. Micoletzky (1917) reported the spear length of *C. rusticum* as 57.5 μ and illustrated the head and tail with blunt ends. The spear of *C. xenoplax* is longer (71-86 μ) and has the head and tail much more rounded than is illustrated by Micoletzky. Goodey (1951) reports the spear of *C. rusticum* as 50 μ. He also pointed out that the spear of *C. rusticum* illustrated by Taylor (1936) actually measured 50 μ.

Cobb (1918) described *C. simile* with a "head surmounted by a flat lip region composed probably of 6 very flat lips placed in a slightly depressed front surface of the first annule. . . . No labial papillae have been seen." No spear measurement was given but it is probable this species is similar to *C. rusticum* as illustrated by Micoletzky and is so considered here. The specimens used by Chitwood (1949) in reerecting *C. simile* had spear measurements of 70-75 μ and therefore were not *C. rusticum*. Further examination of material used by Chitwood will be necessary to determine whether it is the same as *C. xenoplax*.

Criconemoides curvatum n. sp.

♀ : 0.303-0.452 mm.; a= 8.5-12.9; b=3.2-4.5; c=21.9; V=90.8-96.3%.
♂ : 0.364-0.376 mm.; a=20.2-20.9; b= ? ; c=12.8-13.0; T=37.2%.

LARVA. Head and tail bluntly rounded as in female. Sublateral lobes present. Spear 41-46 μ long. Total annules 80-88, no cuticular markings present.

FEMALE (Fig. 2, M-R, X-Y). Oral opening obscure at surface, shows internally as oval slit near base of sclerotization. Conspicuous elevated labial disc surrounds oral opening. Amphid apertures obscure, appear to be narrow, darkened slits on lateral margins of labial disc. Labial disc expands laterally near base to accommodate amphidial pouches. Sclerotization hexaradiate with

innervations in four submedian sectors. Sublateral lobes conspicuous, placed equidistant about labial disc. Ventro-sublateral lobes and dorso-sublateral lobes connected between each other but no connections between sublateral lobes dorso-ventrally. First annule variable, usually divided into four labial plates but may be reduced in number and/or size or divided only in some sectors. First two annules smaller and narrower than succeeding annules but not set off, presenting a bluntly rounded outline.

Spear length 47-67 μ. Excretory pore on 21-29th annule from anterior end. Vulva on 6-10th annule from end of body, generally on 7-8th annule. Anterior flap of vulva variable, usually presents a slightly bilobed appearance but may be simple in outline. Anastomosis with preceding or succeeding annules often complicates vulva pattern. Ovary extends 30.9-70.7% of body length. Anus on 5-6th annule from end of body. Terminus simple, rounded or lobed. Total annules 78-101.

Male (Fig. 2, J-L, S-W). Lip region low rounded, no striae present on lips. Sublateral lobes small, placed equidistant about labial disc. Innervations of amphids present but amphid apertures obscure. Hexaradiate sclerotization delicate, extending approximately four annules posterior to lip region.

Spear absent, esophagus and intestine indistinct. Lateral field marked by four incisures. Excretory pore 88-91 μ from anterior end of body. Hemizonid about 1.5 annules wide, located two annules anterior to excretory pore.

Spicules 27 μ long, definitely curved. Gubernaculum simple, rod-like, 5 μ long. Spicule sheath protrudes conspicuously but lacks the posterior process present in *C. xenoplax*. Body constricts posterior to spicules, coarsely annulated. Tail pointed with rounded terminus. Bursa small, begins slightly anterior to cloacal opening and extends almost to terminus. Lateral lines extend varying distance on bursa.

Males rare, known only from type locality.

Type specimens. Holotype—female, Catalogue #6; allotype—male, Catalogue #7; and 36 paratypes, in Calif. Coll. #265 in Univ. of Calif. Collection, Berkeley.

Type habitat. *Soil taken about the roots of snapdragon* (*Antirrhinum* sp.).

Type locality. Near Colma, San Mateo County, Calif.

Distribution. Collections of this species also taken from soil about the roots of lupine (*Lupinus* sp.) near Capitola, Santa Cruz County, Calif.; at roots of apple (*Malus sylvestris*), Sebastopol, Sonoma County, Calif.; from a home garden in San Francisco, Calif.; from grassy field, Raleigh, N. C.; from vegetable garden, Ellenville, N. Y.; from open field near Stow, Vt.; from potato field near Reno, Nevada.

Diagnosis. *Criconemoides curvatum* is most closely related to *C. xenoplax* from which it differs in the smaller size of males and females and in the shorter spear of females. In addition, the male tail of curvatum is more pointed, the spicules more strongly curved and the lip region less elevated. The larvae have no cuticular markings on the annules which differs from the longitudinal cuticular markings on the larvae of *C. xenoplax*.

This species keys to *C. rusticum* according to Taylor (1936) from which it differs in the possession of sublateral lobes on the lip region and in the rounded shape of the head and tail.

Criconemoides mutabile Taylor, 1936

♀ : 0.266 = 0.412 mm.; a = 10.0-15.3; b = 3.0-5.0; c = 20.0-34.1; V = 89.7-92.9%.

♂ : Unknown.

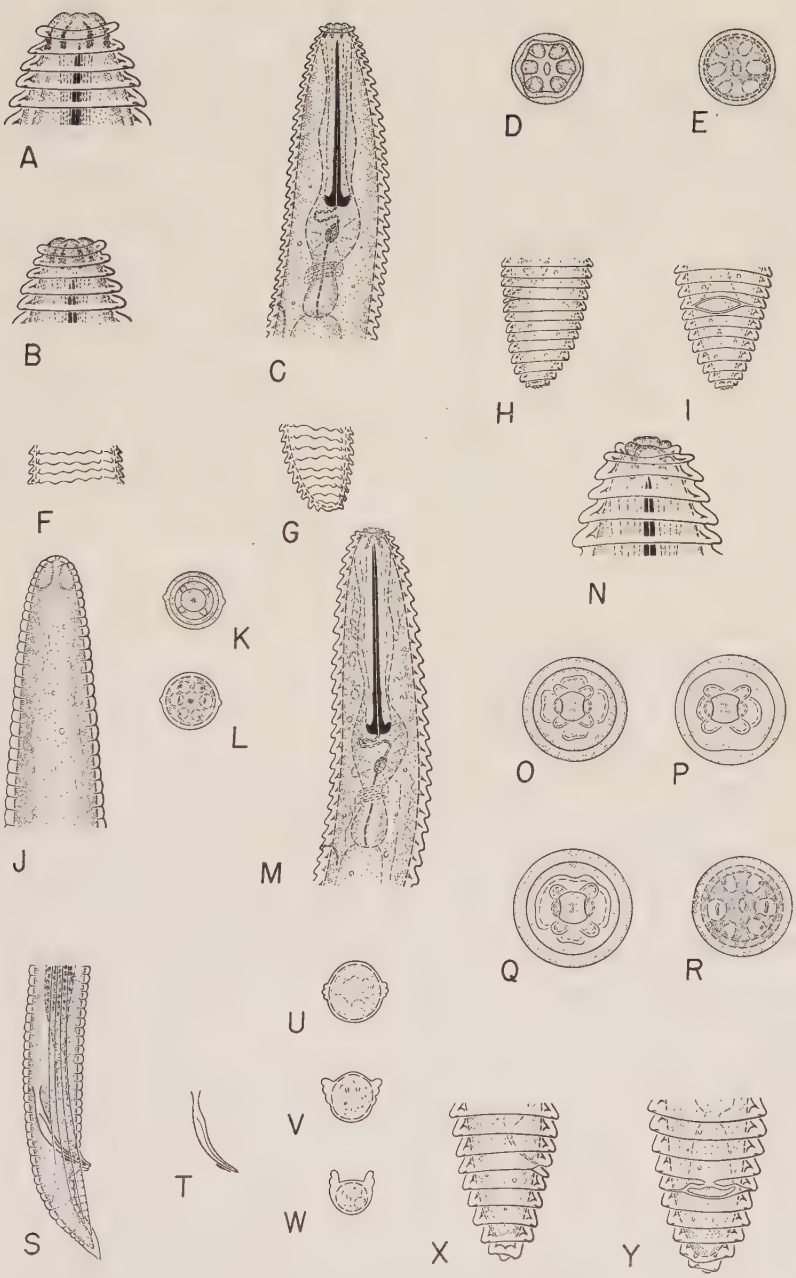

FIG. 2. *Criconemoides mutabile.* A-B—Female lip region; × 1000. C—Female neck region; × 450. D-E—Female face view and sclerotized framework of head; × 1000. F-G—Cuticle pattern of larvae, midway on body and on tail; × 500. H-I—Female tail, lateral and ventral views; × 500. *Criconemoides curvatum.* J—Anterior end of male; × 1000. K-L—Male face view and sclerotized framework of head; × 1000. M—Female neck region; × 500. N—Female lip region; × 1000. O-Q—Female face views; × 1000. R—Female head sclerotization; × 1000. S—Male tail; × 450. T—Male spicule and gubernaculum; × 500. U-W—Cross sections of male tail, anterior to spicules (U), slightly anterior to cloacal opening (V) and posterior to cloacal opening (W); × 500. X-Y—Female tail, lateral and ventral views; × 500.

Larva (Fig. 2, F-G). Spear length 42-47 μ. Total annules 114-115, marked on posterior edge by rounded spines arranged in longitudinal rows. Maximum number of rows 15 about midway on body, decreasing in number toward each end of body.

Female (Fig. 2, A-E, H-I). Cupped anterior surface of first annule bears six low, rounded lips resulting in bluntly rounded appearance. First annule not retrorse, well set off from succeeding body annules. Variations in fixation occasionally telescopes annules slightly and first annule is not always as definitely set off. Second annule slightly larger than first and usually retrorse. A minute papilla present on each of four submedian lips. Amphid apertures obscure.

Spear length 50-58 μ. Excretory pore on 25-32nd annule from anterior end of body. Vulva simple in outline, located on 10-12th annule from terminus. Ovary occupies 40.1-54.8% of body length. Anus on 7-8th annule from terminus. Tail bluntly rounded with complex terminus composed of 3-4 small lobes. Total annules 101-113.

Type specimens.—Neotype—female, Catalogue #14; and 20 homotypes, in Calif. Coll. #247, Univ. of Calif. Coll., Berkeley.

Type habitat. Soil about roots of plum tree.

Type locality. Near Arvin, Kern Co., Calif.

Distribution. Other collections of this species made also in California from soil taken about roots of: strawberries, Santa Maria, Santa Barbara County; avocado tree, Los Angeles County; grape vineyard near Guasti, San Bernardino County; field planted to barley, Kern County; also soil from bank of stream, Berkeley, Alameda County and from a home garden in San Francisco, Calif.

Diagnosis. *Criconemoides mutabile* is most closely related to *C. rusticum* according to Taylor (1936) and is differentiated from *rusticum* on the location of the vulva, tail shape and head annules set off by constriction. The vulva location may be a valid character to distinguish *mutabile* and *rusticum* but does not hold in the case of *C. xenoplax* since the position of the vulva is too variable in the last species. However, the first annule well set off serves to distinguish *mutabile* from both *rusticum* and *xenoplax*. *C. mutabile* also differs from *xenoplax* in the absence of sublateral lobes, the possession of a shorter spear and in the different cuticular pattern on the annules of the larvae.

The California specimens figured here are shorter than those described by Taylor (1936). However, in all other characters the California specimens appear identical to *mutabile* and are considered to represent the extremes of a wider range in size than previously reported.

Criconemoides teres n. sp.

♀ : 0.338-0.420 mm.; a = 11.7-13.1; b = 3.2-3.8; c = ? ; V = 91.8-94.6%.

♂ : Unknown.

Female (Fig. 3, A-E). Oral opening surrounded by low, rounded labial disc. Sublateral lobes lacking. Amphid apertures obscure, narrow, dark slits on lateral margins of labial disc which expands internally near base to accommodate amphidial pouches. Sclerotization hexaradiate with innervations in four submedian sectors. First annule narrow, irregular in outline and smaller than succeeding body annules. Second and succeeding annules retrorse, first annule directed forward slightly but not particularly set off from second annule. Head bluntly rounded.

Spear length 75-76 μ. Excretory pore on 28-30th annule from anterior end. Vulva on 8-9th annule from end of body, simple oval in outline. Ovary extends 46.2-54.5% of body length. Anus on 5-6th annule from end of body. Terminus a simple lobed button. Total annules 106-113.

TYPE SPECIMENS. Holotype—female, Catalogue #4; and 5 paratypes, in Calif. Coll. #162 in Univ. of Calif. Collection, Berkeley.

TYPE HABITAT. Soil about roots of oak, *Quercus* sp.

TYPE LOCALITY. 4½ mi. north of Highway 40 on Green Valley Road, 6 mi. west of Fairfield, Solano Co., Calif.

DIAGNOSIS. *C. teres* keys to *C. rusticum* according to Taylor (1936) and appears to approximate *rusticum* more closely than any of the other species considered here. The low rounded labial disc on the small first annule appears similar to the illustrations of *C. rusticum* but the terminus is different and the longer spear would also serve to distinguish these two species.

The absence of sublateral lobes readily differentiates *C. teres* from *xenoplax, curvatum* and *lobatum*. The longer spear of *teres* further separates it from *curvatum* and *lobatum*.

Criconemoides parvum n. sp.

♀ : 0.259-0.295 mm.; a=11.7-14.5; b=3.0-3.4; c= ? ; V=92.5-95.9%.
♂ : Unknown.

LARVA. Only one young specimen was collected. Head and tail bluntly rounded as in female. Spear length 25 μ. Total annules 156. No cuticular markings discernible.

FEMALE (Fig. 3, F-K). Oral opening obscure, appears to be a narrow slit. Sublateral lobes small, obscure, slightly exaggerated for purposes of illustration. First annule lobed, not definitely set off from succeeding annules. Sclerotization hexaradiate. First five or six annules of anterior end and annules of tail after the vulva rounded, not retrorse. Other body annules only slightly retrorse and somewhat angular in appearance.

Spear length 38-41 μ. Excretory pore on 46-49th annule from anterior end. Isthmus rather slender and elongate. Dorsal gland opening about five μ from spear. Vulva on 11-12th annule from end of body. Anterior flap of vulva faintly bilobed, more prominent in lateral view. Ovary occupies 29.3-35.9% of body length. Anus obscure, appears to be located on 3rd annule from end of body. Terminus simple, rounded, resulting in bluntly rounded tail. Total annules 142-156.

TYPE SPECIMENS. Holotype—female, Catalogue #3; and 12 paratypes in Nevada Coll. #19 in Univ. of Calif. Collection, Berkeley.

TYPE HABITAT. Soil take about roots of *Artemesia* sp.

TYPE LOCALITY. Approximately five miles east of Winnemucca, Nevada.

DIAGNOSIS. *Criconemoides parvum* is most closely related to *C. macrodorum* Taylor, 1936 and differs from *macrodorum* in the greater number of annules, smaller spear and more blunt tail in *C. parvum*.

This species keys to *Criconemoides annulatum* Taylor, 1936, however, *annulatum* is a larger species (0.88-1.00 mm.) with a longer spear (105 μ).

Criconemoides cylindricum n. sp.

♀ : 0.363-0.442 mm.; a=10.1-12.8; b=3.5-4.4; c=15.9; V=90.3-93.8%.
♂ : Unknown.

LARVA. Spear length 43-46 μ. Total annules 94-100. Longitudinal cutic-

ular markings on posterior edge of annules similar to but more strongly developed than in *C. xenoplax*.

Female (Fig. 3, L-Q). Oral opening obscure, surrounded by conspicuous elevated labial disc. Amphid apertures narrow dark slits on lateral margins of labial disc which expands internally near base to accommodate amphidial pouches. Sclerotization hexaradiate with innervations in four submedian sectors. Sublateral lobes small, placed equidistant about labial disc. First annule small, narrow, irregular in outline, never divided into plates as in *C. xenoplax*, not retrorse. Second annule retrorse, not set off from succeeding annules. Head presents a bluntly rounded outline.

Spear length 48-56 μ. Excretory pore on 25-27th annule from anterior end of body. Vulva located on 7-9th annule from terminus. Anterior flap of vulva forms two distinct points in outline. Ovary extends 38.8-71.8% of body length. Anus on 6-8th annule from end of body, often notches posterior edge of the annule. Terminus with two lobes deeply cleft between presenting a bluntly rounded almost truncate tail. Total annules 87-92.

Type specimens. Holotype—female, Catalogue #8; and 18 paratypes, in Georgia Coll. #3 in Univ. of Calif. Collection, Berkeley.

Type habitat. Soil about roots of peanut, *Arachis hypogaea*.

Type locality. Near Albany, Georgia.

Distribution. Other collections taken from soil from peanut fields near Leesburg and in Worth County, Ga.; soil from a corn field, Perry, Ga.; soil from potato field, Fort Myers, Fla.

Diagnosis. *C. cylindricum* is most nearly related to *C. curvatum* and *C. lobatum*. It differs from both species in the absence of labial plates and by the pointed outline of the anterior vulvar flap. It is further differentiated from *curvatum* in the presence of cuticular markings on the larvae and from *lobatum* in the small size of the sublateral lobes and the smaller number of annules.

This species keys to *C. rusticum* according to Taylor (1936). The sublateral lobes of the lip region, the deeply cleft lobes of the terminus and the fewer annules of *cylindricum* differ from *rusticum*.

Criconemoides lobatum n. sp.

♀ : 0.402-0.480 mm.; a=11.3-14.2; b=3.9-4.8; c=25.0; V=93.5-95.1%.

♂ : Unknown.

Larva. Sublateral lobes prominent as in adult presenting truncate appearance to head. Spear length 42-48 μ. Excretory pore on 31st annule. Total annules 104-105 marked on posterior edge by longitudinal lines as in *C. xenoplax*.

Female (Fig. 4, A-F). Oral aperture obscure, surrounded by indistinct labial disc. Sublateral lobes unusually large, projecting forward as far as or slightly anterior to labial disc. Sublateral lobes flattened on anterior surface resulting in a truncate appearance to head. Amphid apertures small narrow slits. Sclerotization hexaradiate with innervations in four submedian sectors. First annule divided into four labial plates with the dorsal and ventral plates reduced in size. Sublateral lobes and first annule set off by constriction from second and succeeding body annules which are retrorse.

Spear length 51-55 μ. Excretory pore on 31st annule from anterior end. Dorsal gland opening about five μ from spear. Vulva opening simple, located on 7-8th annule from end of body. Ovary extends 41.1-50.6% of body length.

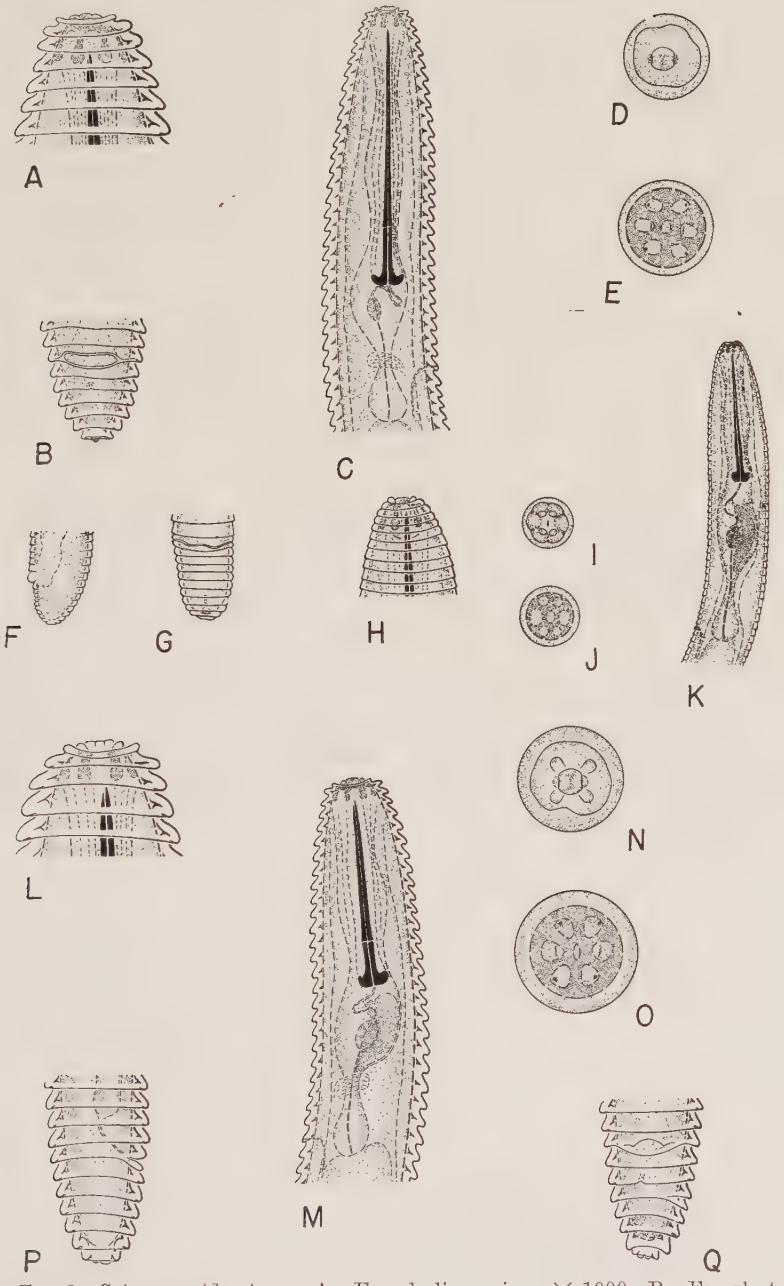

FIG. 3. *Criconemoides teres.* A—Female lip region; × 1000. B—Female tail, ventral view; × 500. C—Female neck region; × 450. D-E—Female face view and sclerotized framework of head; × 1000. *Criconemoides parvum.* F-G—Female tail, lateral and ventral views; × 500. H—Female lip region; × 1000. I-J—Female face view and sclerotized framework of head; K—Female neck region; × 450. *Criconemoides cylindricum.* L—Female lip region; × 1000. M—Female neck region; × 450. N-O—Female face view and sclerotized framework of head; × 1000. P-Q—Female tail, lateral and ventral views; × 500.

Anus on 5-6th annule from end of body. Terminus directed slightly dorsad, somewhat truncate with 2-3 small lobes. Total annules 99-107.

Type specimens. Holotype—female, Catalogue #5; and 13 paratypes, in New York Coll. #10 in Univ. of Calif. Collection, Berkeley.

Type habitat. Soil from potato field.

Type locality. Near Richfield, New York.

Distribution. Other collections of this species from potato field near Reno, Nev.; sod from La Guardia Airport, N. Y.; home garden, Ellenville, N. Y.

Diagnosis. *C. lobatum* is closely related to *C. xenoplax* and *C. curvatum* and keys to *C. rusticum* according to Taylor (1936). It is differentiated from all three species in the presence of the prominent sublateral lobes which present a truncated appearance to the head . The shorter spear of *lobatum* further differentiates it from *xenoplax*. There are generally fewer annules in *curvatum* than in *lobatum*.

Criconemoides informe (Micoletzky, 1921) Taylor, 1936

♀ : 0.430-0.502 mm.; a=8.0-9.7; b=3.5-3.8; c= ? ; V=91.7-94.8%.

♂ : Unknown.

Female (Fig. 4, G-M). Oral aperture obscure at surface, surrounded by conspicuous elevated labial disc. Amphid apertures obscure, narrow elongate slits on lateral margins of labial disc which broadens at base to include amphidial pouches internally. Sublateral lobes lacking or obscure and incompletely formed. First annule small and irregular in outline. Second annule larger than first but smaller than succeeding body annules and set off by a distinct elevation. First two annules not retrorse. Sclerotization hexaradiate with innervations in four submedian sectors.

Spear length 71-81 μ. Excretory pore on 19th annule from anterior end. Vulva a simple, narrow slit located on 6-8th annule from end of body. Anus on 3-4th annule from end of body. Ovary extends 48.8% of body length. Terminus simple rounded or lobed button presenting bluntly rounded tail. Total annules 60-65.

Type specimens. Neotype—female, Catalogue #15; and 4 homotypes, in Colorado Coll. #10, Univ. of Calif. Collection, Berkeley.

Type habitat. Soil about roots of aspen, *Populus tremuloides*.

Type locality. Near Idaho Springs, Clear Creek Co., Colorado.

The specimens illustrated here closely fit the description given by Micoletzky (1921). *C. informe* is most nearly related to *C. sphaerocephalum* Taylor, 1936 which is smaller (0.3 mm.), with shorter spear (57 μ) and possesses a broken lateral line lacking in *informe*.

Key to the species of *Criconemoides*

1. Spear length 100 μ or more 2
   Spear length 90 μ or less 5
2(1). Total body annules 95 or more 3
   Total body annules 58-61 ..... *annulifer* (deMan.)
3(2). Length 0.450 mm. or more; spear not very long and thin (less than ⅓ of body length) 4
   Length 0.270-0.300 mm.; spear very long and thin (more than ⅓ of body length) ..... *macrodorum* Taylor.
4(3). Spear 105 μ; total body annules 140; length 0.880-1.000 mm. ..... *annulatum* Taylor.

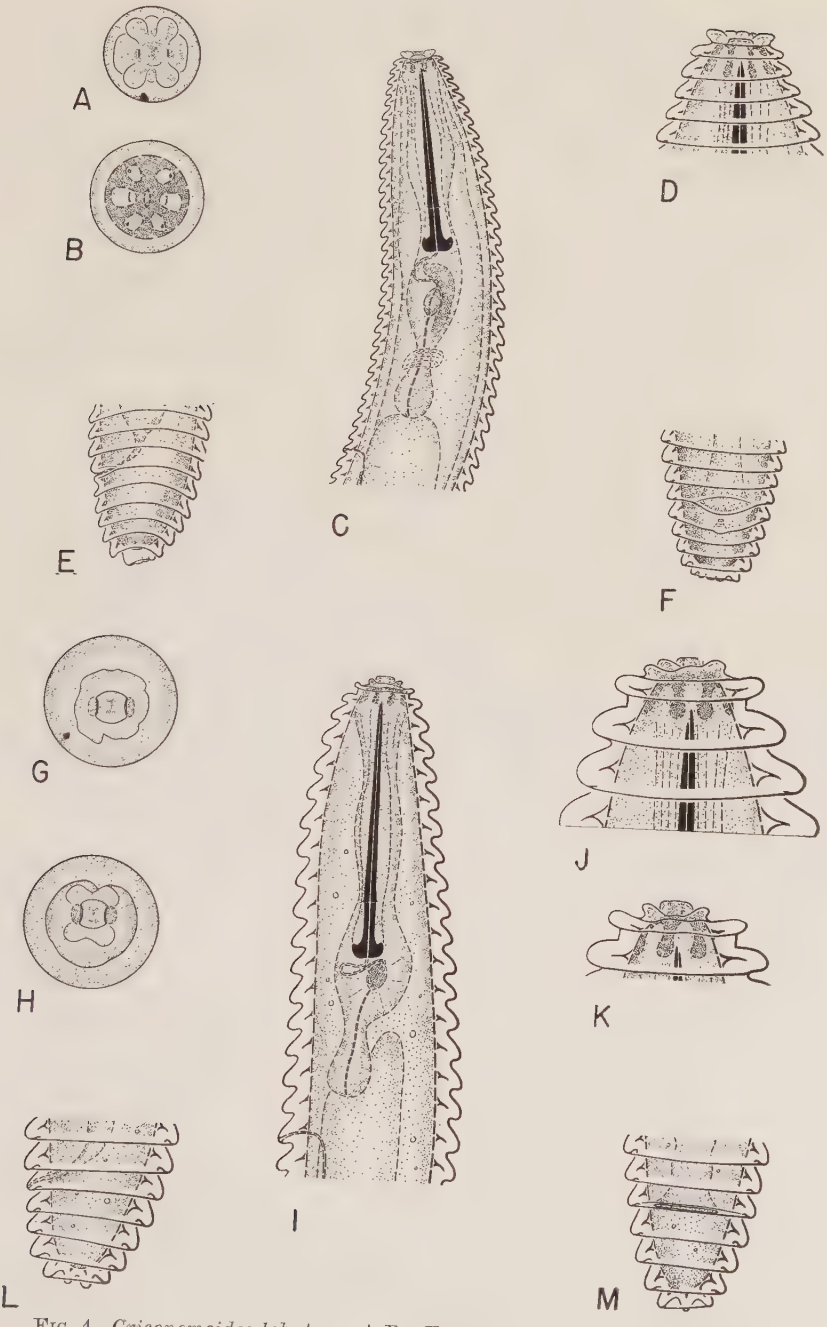

FIG. 4. *Criconemoides lobatum.* A-B—Female face view and sclerotized framework of head; × 1000. C—Female neck region; × 450. D—Female lip region; × 1000. E-F—Female tail, lateral and ventral views; × 500. *Criconemoides informe.* G-H—Female face views; × 1000. I—Female neck region; × 450. J-K—Female lip region; × 1000. L-M—Female tail, lateral and ventral views; × 450.

Spear 122 μ; total body annules 95-103; length 0.456 mm. ..... *sphagni* (Micoletzky)

5(1). Tail pointed 6
Tail rounded 11

6(5). Total body annules 110 or more 7
Total body annules less than 80 8

7(6). Length 0.700 mm.; vulva on 16-17th annule from terminus ..... *komabaensis* (Imamura).
Length 0.550-0.590 mm.; vulva on 8th annule from terminus ..... *morgense* (Hofmänner & Menzel).

8(6). Total body annules 70 or more 9
Total body annules 65 ..... *heideri* (Stefanski).

9(8). Vulva located on 12-15th annule from terminus; total body annules 70-76 10
Vulva located on 7th annule from terminus; total body annules 79 ..... *peruense* (Steiner).

10(9). Length 0.700 mm.; first annule larger than second annule ..... *crotaloides* (Cobb).
Length 0.400-0.485 mm.; first annule smaller than second annule ..... *demani* (Micoletzky).

11(5). Joints on lateral line except on anterior end of body 12
No joints on lateral line, annules unbroken except occasional anastomosis 13

12(11). Lateral line zig-zag; spear 57 μ ..... *sphaerocephalum* Taylor.
Lateral line with simple breaks; spear 50 μ ..... *citri* Steiner.

13(11). Total body annules 115 or less; spear 48 μ or more 14
Total body annules 142 or more; spear 38-41 μ ..... *parvum* Raski.

14(13). Total body annules more than 73 15
Total body annules 60-65 ..... *informe* (Micoletzky)

15(14). Spear length 70-86 μ 16
Spear length 48-67 μ 18

16(15). Sublateral lobes absent 17
Sublateral lobes present ..... *xenoplax* Raski.

17(16). Total body annules 106-113; length 0.338-0.420 mm. ..... *teres* Raski.
Total body annules 73; length 0.532 mm. ..... *congolense* (Stekhoven & Teunissen).

18(15). Sublateral lobes not prominent or flattened anteriorly 19
Sublateral lobes prominent, flattened anteriorly presenting a truncated head ..... *lobatum* Raski.

19(18). First annule not well set off; cuticle of larvae smooth or with delicate fringe 20
First annule well set off; cuticle of larvae provided with rows of spines ..... *mutabile* Taylor.

20(19). Length 0.303-0.452 mm.; head and tail not blunt—truncate (tail of *cylindricum* somewhat truncate) 21
Length 0.600 mm.; head and tail both blunt—truncate ..... *rusticum* (Micoletzky).

21(20). Anterior flap of vulva forming 2 definite points; larvae with longitudinal cuticular frings ..... *cylindricum* Raski.
Anterior flap of vulva bilobed, rounded; larvae without cuticular markings ..... *curvatum* Raski.

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Potassium Nutrition of the Host in Relation to Infection by a Root-Knot Nematode *Meloidogyne incognita*

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Several workers (Spencer & McNew, Thomas, Walker) have observed that the reaction of certain plants to pathogenic agents may be altered by varying the mineral composition of the nutrient solution supplied to the plant. As far as can be determined comparatively little work has been done in regard to such influence on the reaction of host plants to parasitic nematodes. Wilfarth and Wimmer (1903), found that nematode infected sugar beets had lower percentages of nitrogen, potassium, sodium, calcium and magnesium.

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They concluded that the plants were deprived of nutritional substances due to the presence of nematodes, and stipulated that an abundant potassium fertilization would maintain the proper sugar content within the beets but would not prevent a lowering of the yield. Roemer (1927), however, was able to increase the yields of nematode infected sugar beets from 18,000 to 19,000 kg. per 2.47 acres by applying only a potassium fertilizer. Tarjan (1950), analyzed boxwood plants infected with meadow nematodes, *Pratylenchus* spp. (Steiner, 1948) and found that infected plants suffered from deficiencies of essential elements. It can therefore be seen that in cases of some plant nematode diseases, there is a marked reduction in certain of the nutritional elements contained in the plants.

In connection with experiments being conducted in this laboratory[2] with root knot of lima beans, the causal agent of which is *Meloidogyne* spp. (Chitwood, 1949), it seemed desirable to ascertain whether the host-parasite relationship of this disease could be modified by mineral nutrition. A study was undertaken to determine the influence of potassium nutrition on the reaction of lima bean plants to one of the species of root-knot nematodes, *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949.

Materials and Methods

Inoculum of the nematode species *Meloidogyne incognita* was propagated in the greenhouse on roots of tomato plants, *Lycopersicon esculentum* Mill. var. Marglobe. The number of egg masses contained in a finely chopped weighed sample of roots was counted microscopically and the corresponding weights of roots containing approximately 50 and 200 egg masses were computed.

Glazed, 3-gallon crocks provided with drainage were filled to one-quarter of their capacity with a coarse sand on top of which a finer sand was added until the crock was about half full. The required amount of inoculum containing 50 or 200 egg masses in each case was then distributed evenly over the surface, after which an additional layer of the fine sand was added bringing the surface to about 2 inches from the top of the crock. Lima bean seedlings, *Phaseolus lunatus* L. var. Henderson, germinated in pure sand were transplanted to the crocks when in the 3- or 4-leaf stage.

Nutrient solutions in distilled water were prepared from normal stock solutions of the following C.P. salts: $Ca(NO_3)_24H_2O$, KNO_3, $NaNO_3$, KCl, $MgSO_4$, KH_2PO_4 and NaH_2PO_4. The composition of the nutrient solutions supplied are shown in table 1. No attempt was made to adjust the pH of

TABLE 1

Composition of the Nutrient Solutions*

Treatment designation	Milliequivalents per liter							
	Ca	Mg	K	Na	NO_3	H_2PO_4	SO_4	Cl
K_1	10.0	4.0	0.5	10.0	15.0	1.0	4.0	4.5
K_2	10.0	4.0	6.0	4.5	15.0	1.0	4.0	4.5
K_3	10.0	4.0	10.0	0.5	15.0	1.0	4.0	4.5

* In addition a micronutrient solution as described by Hoagland and Snyder (1933) was added to each treatment.

[2]This experiment was carried out in cooperation with the Division of Nematology, Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md.

the nutrient solutions, which varied between 5.8 to 6.4.

The potassium concentrations were selected on the basis of a preliminary test. Treatment K_1 was expected to result in potassium deficiency, treatment K_2 to result in optimal growth and treatment K_3 to provide excessive potassium. The solutions were supplied at the rate of 250 ml. daily for the first week, after which applications of 400 ml. of nutrient solutions were added three times a week. Crocks were flushed weekly with tap water in order to prevent any accumulation of salts.

The experimental design was a randomized complete block with four replications. During the course of the experiment greenhouse temperature varied from 65° to 85° F., with an average of 75° F.

After 70 days the plants had reached maturity. The roots were washed free of sand and rinsed in tap water. After drainage for a few seconds remaining free water was blotted from them with toweling. Fresh weights of the complete plants were determined. All the leaves removed from each plant were then kept separately in a paper bag. The remains of the plant were also kept in another paper bag. The plants were then dried in an oven for 48 hours at approximately 125° F. The total dry weight of each plant was then recorded. Leaves were ground in a Wiley mill equipped with a 60-mesh wire screen. Ash solutions were prepared and analyzed for phosphorus, magnesium, calcium, and potassium. Total nitrogen including nitrates was determined by the micro-Kjeldahl apparatus according to the method described by Ranker (1927), modified by using 2% boric acid to catch the distillate. Potassium and calcium were determined by the use of the Beckman flame spectrophotometer. Magnesium readings were obtained by the use of Leitz photoelectrometer. Phosphorus was determined essentially by the official methods (Assoc. Off. Agric. Chem., 1940). Leaves of each plant were analyzed separately with two replicates of each plant.[3] Analysis of variance was applied to the analytical data as well as to the growth data.

RESULTS

GROWTH RESPONSE. As measures of total growth, the fresh weight per plant and total dry weight per plant are used. These results as well as those for percentage dry matter for the whole plants are shown in table 2. Data reveal that the growth of uninoculated plants increased as the potassium concentration increased from K_1 to K_2 treatment. Treatment K_3 had resulted in an insignificant increase in fresh weight as well as in dry weight when compared to K_2 treatment. The growth of inoculated plants was significantly reduced as compared to uninoculated plants when the level of K nutrition was similar. But the growth of inoculated plants significantly increased when potassium supply increased from K_1 to K_2 to K_3. From the data it is also evident that plants infected with 50 egg masses and supplied with excessive potassium made almost the same growth as the plants in treatment K_2 as determined by dry weight measures. Percentage dry matter for the whole plants did not differ significantly among treatments.

MINERAL CONTENT. The total amount of certain mineral elements of uninoculated plants and inoculated plants are recorded in table 3. It is evident that uninoculated plants contained a higher amount of these elements than the infected ones. In the growth data (table 2) it is shown that between the

[3]The author expresses sincere appreciation to Dr. L. E. Scott, Department of Horticulture, University of Maryland, for his valuable suggestions and guidance during the execution of the chemical determinations involved.

TABLE 2

Average Total Fresh Weight, Total Dry Weight and Percentage Dry Matter of Lima Bean Plants

Treatment	Total fresh weight grams per plant	Total dry weight grams per plant	Percentage dry matter
K_1	113.2	22.6	19.9
K_2	203.3	38.6	19.0
K_3	208.5	39.5	19.0
50*EMK_1	99.5	19.9	20.0
50EMK_2	147.4	28.0	19.0
50EMK_3	180.5	36.1	20.0
200EMK_1	89.1	16.0	19.0
200EMK_2	100.9	19.1	19.0
200EMK_3	113.0	22.5	20.0
Difference required for significance			
0.05	9.67	1.82	n.s.
0.01	13.06	2.46	n.s.

*EM—Egg masses, indicating that 50 or 200 egg masses were used as inoculum and the pot received nutrient solution with varying amounts of potassium.

TABLE 3

Average Total Amount of Mineral Content of Plants Grown in Nutrient Solution with Variations in Potassium and in Level of Nematode Inoculation

Grams per plant Treatment	K	Ca	Mg	N*	P**
K_1	0.091	2.07	0.330	0.617	0.321
K_2	1.118	2.87	0.600	0.881	0.365
K_3	1.733	2.91	0.602	0.925	0.392
50EMK_1	0.065	1.82	0.283	0.415	0.214
50EMK_2	1.039	2.25	0.463	0.540	0.222
50EMK_3	1.250	2.67	0.639	0.752	0.311
200EMK_1	0.054	1.22	0.224	0.280	0.125
200EMK_2	0.586	1.32	0.250	0.381	0.133
200EMK_3	0.725	1.93	0.432	0.652	0.223
Difference required for significance					
0.05	0.052	0.26	0.048	0.050	0.028
0.01	0.071	0.35	0.065	0.070	0.038

*as Total nitrogen. **as P_2O_5.

treatments K_2 and K_3 there were no significant differences in total dry weight or fresh weight. A similar situation as far as the amount of minerals contained in the previous two treatments also exists, except that potassium content in K_3 treatment was significantly higher. This condition indicates what is known as "luxury absorption" when the content of the potassium in the tissue increases without increase of growth. On the other hand, the amount of mineral elements of infected plants increased when potassium concentration of the nutrient solution increased. Data indicate that infected plants with a relatively moderate amount of inoculum (50 egg masses) and supplied with excessive potassium maintained mineral levels comparable with that of con-

trol plants in K_2 treatment. However, with a heavy amount of inoculum (200 egg masses) the excessive amount of potassium supplied was apparently, under the condition of this experiment, not enough to maintain a proper mineral level as compared to control plants.

The figures in table 4 are the differences between average weights of mineral elements in plants from K_2 and K_3 treatments. It will be noted that as the number of egg masses used for inoculum was increased these differences became progressively less for potassium and progressively greater for the other elements.

TABLE 4

AVERAGE DIFFERENCES IN ABSORPTION OF CERTAIN MINERAL ELEMENTS, IN THE CASE OF LIMA BEAN PLANTS INFECTED BY *Meloidogyne incognita*, WHEN POTASSIUM CONCENTRATION OF THE NUTRIENT SOLUTION IS INCREASED FROM OPTIMUM TO EXCESSIVE LEVELS

Nematode inoculum	Grams per plant				
	K	Ca	Mg	N	P
0 egg mass	0.615	0.004	0.002	0.044	0.027
50 egg mass	0.211	0.042	0.176	0.212	0.089
200 egg mass	0.139	0.061	0.180	0.271	0.090

DISCUSSION

The growth of the plants in this experiment is conditioned by two factors; infection by nematodes and supply of potassium. As far as the data are concerned the root-knot nematode, *Meloidogyne incognita*, caused a general reduction in plant growth, as determined by total fresh and total dry weights. Such a reduction in growth was evident with the increase in the number of nematodes. On the other hand, an increase in the concentration of potassium supplied to infected plants generally produced an increase in plant growth. Excessive amount of potassium supplied to uninoculated plants did not result in a significant increase in total growth as compared to those which received an optimum amount of potassium. However, such increase in growth was highly significant when an excessive amount of potassium is supplied to inoculated plants. Chemical analysis showed that infected plants had lower total amounts of nitrogen, phosphorus, calcium, magnesum, and potassium as compared to control plants. The rate of absorption of these elements was affected by the presence of the nematodes. In case of uninoculated plants, when potassium supply increased from optimum to excessive levels, potassium absorption increased while the absorption of the other elements did not significantly increase. This balance was changed when nematodes were introduced to the plants. An increase in nematode inoculum correspondingly decreased the amount of potassium absorbed while the absorption of the other elements was considerably increased. Data indicated that plants infected with a relatively moderate amount of inoculum and supplied with an excessive amount of potassium made almost normal growth and maintained mineral levels comparable with that of the uninoculated plants. Previous work by the author (Oteifa) showed that the rate of oviposition of *M. incognita* is correspondingly increased when potassium supply of the host increased. It appears that nematode damage is correlated with the amount of available potassium to the host plant. Such a correlation suggests

that nematodes interfere in some manner with the potaissum nutrition of the plant, and thus may cause a marked injury when introduced to plants deficient in potassium.

In conclusion it is evident that the root-knot nematodes affect the mineral content and physiology of the host plant and that damage caused by the nematodes may be reduced by increasing the level of potassium supplied to the plant.

These effects may be due to the fact that: (1) Root systems of plants infected by root-knot nematodes are much reduced and therefore absorb nutrients from a smaller volume of soil than the roots of healthy plants. (2) The knots produced by the nematodes involve the conducting tissue of the roots and thus interfere with the translocation of nutrients. (3) Because of the interference of the nematodes with the root system the metabolic activities of the plants could conceivably be altered. (4) Possibly the differential absorption of potassium shown by the plants was due in some degree to the use of this element by the nematodes in their nutrition and egg production.

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Notes on Regeneration in the Rhizocephala (Crustacea)

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In certain gregarious Rhizocephala such as Gemmosaccus[1] and Thompsonia each external sac withers and falls off after the embryos have been released; the internal root system then develops a new generation of visceral sacs that emerge to the exterior at the next molt of the host (Potts, 1915; Pérez, 1928, 1931). This is a type of asexual reproduction, but not regeneration in the usual sense of the word since the new sacs are not individual replacements of the previously existing ones.

In the solitary types of Rhizocephala proof that any similar replacement occurs is lacking. Day (1935) and Veillet (1945) studied the fate of Sacculina after the falling off of the visceral sac. Day concluded that a new external sac is regenerated from the internal root system, but Veillet found no evidence of regeneration in the 36 cases he studied and interprets the observations of Day in a different manner. The occurrence of a new visceral sac on a host that has lost a previous one may be explained by polyembryony or by double infestation where the second Sacculina did not emerge until some time after the first had dropped off.

The lack of any reports in the literature of a direct experimental approach to the problem of regeneration in the Rhizocephala and the fact that there is no case on record of the finding in nature of a young Rhizocephalid emerging directly from the scar left by an old sac prompts the publication of the present note.

EXPERIMENTS

On July 28, 1939, at Lamoine, Maine, the author cut off the 7 mm. external sac of a young *Peltogaster paguri* Rathke occurring on the abdomen of the host crab, *Pargurus pubescens* Kröyer. This crab was kept alive until August 19, 1939 when it was killed and prepared for sectioning. At the point of amputation a cap of chitin had formed, apparently secreted by the cells of the parasite which were proliferated from the tissue lining the inside of the original stalk of attachment. Underneath this scar was a rather large cavity filled with a fluid, presumably lymph. It is likely that, after the visceral sac is removed, the roots of the parasite continue absorbing nourishment, which collects at the base of the stalk, since the normal outlet is now blocked off. There was no histological evidence that a new externa was being regenerated.

More extensive experiments were undertaken in July, 1950, at Rockport, Texas, where the sacculinid *Loxothylacus texanus* Boschma is a common parasite of the blue crab, *Callinectes sapidus Rathbun,* in Aransas Bay. Twenty-seven crab hosts were used, ranging in size from 44 mm. to 80 mm. carapace width and comprising about equal numbers of males and females. Each crab carried a single Loxothylacus and these represented all sizes of the parasite from small recently emerged sacs to the largest mature sacs. The external portion of the parasite was cut off at the stalk and the crabs placed in individual wire cages suspended in the Bay. The hosts were kept well supplied with food and inspected at frequent intervals.

[1]Formerly known as Chlorogaster.

Although about half the crabs died within the first week or ten days following the removal of the parasite, others remained alive for periods up to 105 days. Three survived at least one month, two lived for nearly two months and one survived for more than three months. In no case was there any regrowth of the sac of the parasite or any external indications of a regenerative process.

Occurrence in Nature

An abnormal *Peltogaster paguri* Rathke, in all probability a new visceral sac growing out of an old stalk, was collected in Frenchman's Bay, Maine, on July 31, 1941. The crab host, *Pagurus pubescens* Kröyer, had a small red Peltogaster measuring 3.5 mm. in length attached to the abdomen alongside the second pleopod. The stalk and chitinous shield, however, were disproportionally large, equal in size to the peduncular portions of a mature parasite. (Fig. 1). The sac did not possess a mantle opening, and the broader end, which is normally the anterior end in this species, was covered over with an irregular mass of hardened whitish tissue. Dissection of the host showed that the internal root system was that of an old parasite; no young roots were found.

Fig. 1. A small abnormal *Peltogaster paguri* Rathke, 3.5 mm. in length, growing out of the scar left by an old sac.

From this parasite, fixed in Gilson's fluid, serial sections were prepared (Fig. 2) which showed the anatomical details very clearly. The external cuticle, hypodermis and mantle musculature were well developed but no internal cuticle or mantle cavity were present. In some cases the muscle fibers of the mantle appeared to be continuous with those of the visceral mass. The ovarian part of the visceral mass consisted of an amorphous ground sub-

stance with some connective tissue cells, muscle fibers and a few small eggs lacking yolk. No trace of colleteric glands could be found.

The male genital organs, small posteriorly but becoming very large anteriorly, were without a distinct lumen or definite external boundaries. There was no division into testes proper and vasa deferentia. The cells making up the testicular tubes lacked the normal concentric arrangement and appeared to spread out in a more or less unorganized manner. Moreover, they exhibited an eosinophilic reaction. The irregular cap of tissue at the anterior end proved to be a solid mass of chitin-like material. It may represent the plug that filled the opening of the old scar, a plug that might adhere to the new sac if it were lifted off by a new growth emerging from within.

It is clear that this Peltogaster could never have produced young and that if the sac was the result of regeneration the process was at best imperfect and resulted in serious malformations.

Fig. 2. Photomicrograph of transverse section through the region of the stalk of the regenerating Peltogaster shown in Figure 1.

Summary

The visceral sac of the rhizocephalid *Loxothylacus texanus* Boschma was amputated in 27 cases but none of the parasites regenerated a new externa. A small *Peltogaster paguri* Rathke found attached to the crab host by a disproportionally large stalk is described as a possible case of regeneration occurring in nature, although the regenerative process was imperfect and gave rise to serious deformities.

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Taxonomic status of the bud and leaf nematodes related to *Aphelenchoides fragariae* (Ritzema Bos 1891)

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The nematode genus *Aphelenchoides* Fischer 1894 contains several related species that are frequently encountered as pests of the foliage and flowering parts of plants. The literature concerning these species is extremely confusing regarding their identification and morphology. A number of authors have made extensive reviews of the literature on the plant parasitic *Aphelenchoides* (Goodey 1928, 1933, Steiner and Buhrer 1932, Crossman and Christie 1936, Filipjev and Stekhoven 1941 and Franklin 1950). In all of these reviews it has been indicated that it is exceedingly difficult or impossible to separate the species closely related to *Aphelenchoides fragariae* (Ritzema Bos 1891) Christie 1932 on the basis of morphological characters. In addition to *A. fragariae* the following species have been described in this group of plant parasites: *Aphelenchoides olesistus* (Ritzema Bos 1893) Steiner 1932, *Aphelenchoides ritzema-bosi* (Schwartz, 1911) Steiner, 1932, *Aphelenchoides ribes* (Taylor, 1917) Goodey, 1933, *Aphelenchoides subtenuis* (Cobb, 1926) Goodey, 1933, *Aphelenchoides besseyi* Christie, 1942, *Aphelenchoides pseudolesistus* (Goodey, 1928) Goodey, 1933, *Aphelenchoides olesistus* var. *longicollis* (Schwartz, 1911) Goodey, 1933 and *Aphelenchoides oryzae* Yokoo 1948. At one time or another all of these species with the exception of *A. besseyi*, *A. pseudolesistus* and *A. oryzae* have been placed in synonomy with *A. fragariae*. However, this concept has not been widely accepted, primarily because of differences in host plant relationships among populations collected from different plants. Franklin (1950) has called attention to the morphological similarity of *A. fragariae* and *A. olesistus* and the confusion that has existed in England concerning the identity of the species of *Aphelenchoides* occurring on strawberry. She has placed *A. olesistus* in synonomy with *A. fragariae* on the basis of host plant transfers and the absence of morphological differences. As indicated by Franklin (1950) the author is in agreement with this conclusion.

The separation of species in this group of *Aphelenchoides* should be based upon morphology since it has been demonstrated by several authors that host plant transfers are not a reliable criterion upon which to base species determinations (Steiner, 1932, Franklin, 1950). It has been found

through study of the group that certain of the species possess well-defined morphological characters that have not been reported previously. These species are here redescribed and since the original authors did not designate types for the species concerned neotypes have been designated. The conclusions drawn are based upon a study of more than two thousand specimens collected over a period of nearly 15 years. These specimens are on slides in the University of California Nematode Survey Collection and are available for study by others interested in the group. The writer is indebted to Mr. Gerald Thorne, Dr. T. Goodey, Dr. M. T. Franklin, Dr. J. R. Christie, Dr. E. M. Cralley, Dr. J. W. Hendrix, and Mr. M. Ichinohe for kindly supplying specimens that were needed to complete this study.

The genus *Aphelenchoides* Fischer, 1894 is characterized as follows: Cuticle marked by fine transverse striae. Lateral field marked as longitudinal incisures. Lip region set off from body. Six lips supported by six-radial internal sclerotization. Cheilorhabdions conspicuous near oral aperture. Lips not annulated. Spear with or without basal knobs. Medial esophageal bulb well developed. Intestine joining esophagus immediately behind bulb. Nerve ring encircling anterior ends of intestine and the esophageal glands. Esophageal glands free in the body cavity, lying along side the intestine. Single anteriorly directed ovary, oocytes in tandem or multiple. Posterior uterine branch present or absent. Mail tail without bursa or gubernacculum. Three pairs of ventro-submedian papillae usually present on male tail. Spicules paired, ventrally arcuate. Female and mail tales never elongate filiform. Type species—*Aphelenchoides parietinus* (Bastian, 1865) Steiner 1932.

KEY TO THE SPECIES OF BUD AND LEAF NEMATODES

1. Head swollen, wider than neck, 4 lines in wing area 2
   Head not swollen, 2 lines in wing area ..... *A. fragariae*
2. Length of posterior-uterine branch 5 or more times body width 3
   Length of posterior-uterine branch less than 4 times body width ..... *A. besseyi*
3. Tail bluntly rounded, armed by a single ventral spine ..... *A. subtenuis*
   Tail terminus peg-like, armed with 4 small mucrons ..... *A. ritzema-bosi*

Aphelenchoides fragariae (Ritzema Bos 1891) Christie 1932 (Fig. 1, A-F)

SYNONYMS:

Aphelenchus olesistus, Ritzema Bos, 1893.
Aphelenchoides olesistus, Steiner, 1932.
Aphelenchus olesistus var. *longicollis,* Schwartz, 1911.
Aphelenchoides olesistus var.*longicollis,* Goodey, 1933.
Aphelenchoides longicollis, Filip. and Stek, 1941.
Aphelenchus pseudolesistus, Goodey, 1928.
Aphelenchoides pseudolesistus, Goodey, 1933.
Aphelenchus omerodis, Ritzema Bos, 1891, in part.

FEMALES*: L, 0.45-0.8 mm.; a, 45-60; b, 8-15; c, 12-20; V, 41-22** 64-71.11-18***

MALES*: L, 0.48-0.65 mm.; a, 46-63; b, 9-11; c, 16-19; T, 44-61.

*Extremes of measurements—L = length; a = length divided by greatest width; b = length divided by length of oesaphagus; c = length divided by length of tail; V = position of the vulva in percentage of body length measured from the anterior end; T = end of tests in percentage of body length measured from the cloaca.

**Position of the anterior end of the ovary in percentage of body length measured from the vulva.

***Position of the posterior end of the uterine branch in percentage of body length measured from the vulva.

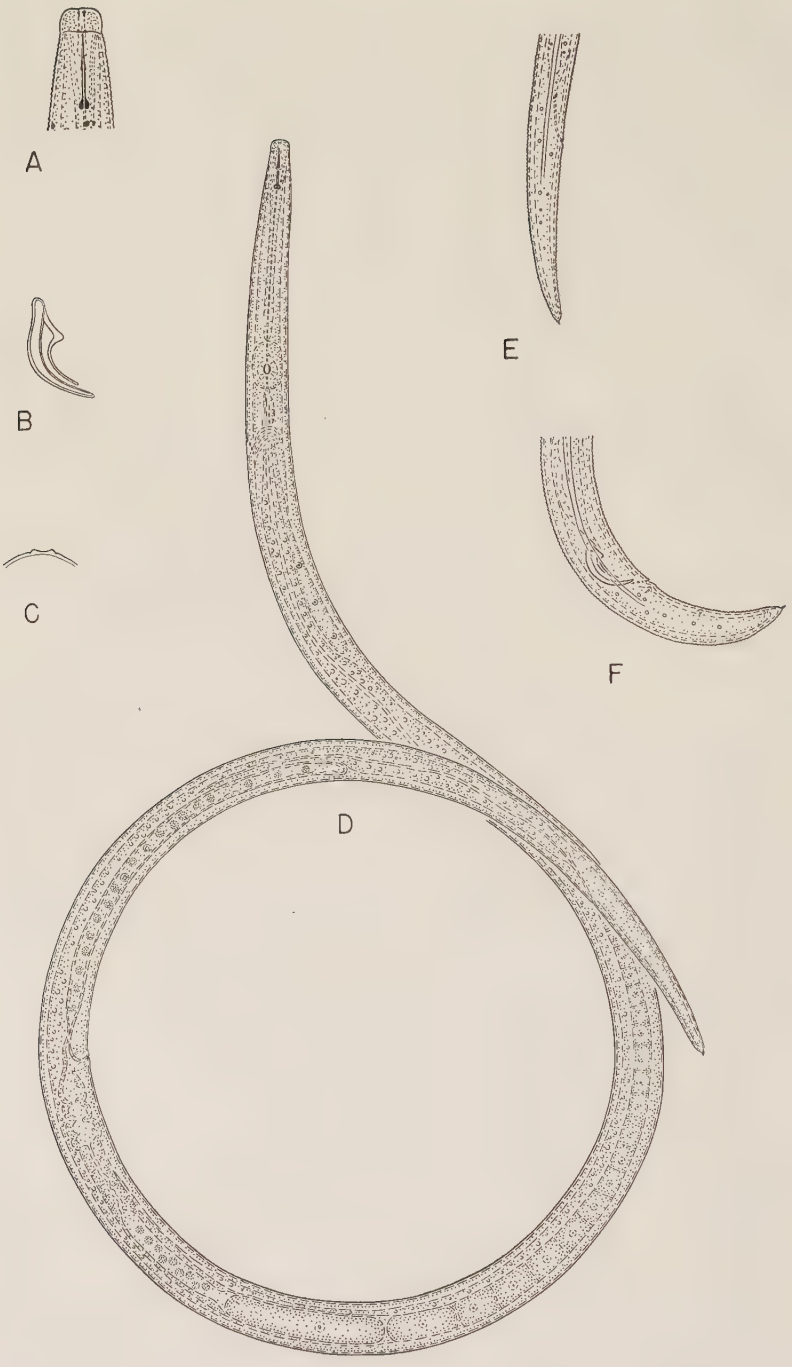

Fig. 1. *Aphelenchoides fragariae*. A—Head; ×1000. B—Spicule; ×1000. C—Lateral field; ×1000. D—Female; ×500. E—Female tail; ×500. F—Male tail; ×500.

FEMALE: (Neotype): Length 0.73 mm.; a—45; b—11; c—13; vulva 66%; ovary 41%; posterior uterine branch 18% (8 times the body width). Body slender. Cuticle marked by fine transverse striae. Lateral field a narrow band occupying about 1/7 of body diameter, marked by two incisures. Lip region almost continuous with neck contour. Lips without annulation. Six-radial sclerotized framework of head delicate. Spear 10 μ long, slender, with well-developed knobs. Median esophageal bulb well developed. Nerve ring about one body width behind median bulb. Excretory pore at or about level of nerve ring. Esophageal glands extending five body widths behind median bulb, joining esophagus immediately behind bulb. Anterior portion of intestine a slender tube joining esophagus immediately behind median bulb. Oocytes arranged in tandem. Posterior uterine branch usually containing spermatozoa. Tail tapering, terminus armed with a single mucronate point enlarged at the base.

MALE (Neotype): Male tail curved to about 45 to 90 degrees when relaxed with gentle heat. Three pairs of ventro-submedian copulatory papillae. First pair slightly post-anal, second pair midway, third pair near end. Spicules ventrally curved, the ventral piece with a moderately well-developed ventral process at the distal end.

DIAGNOSIS: *A. fragariae* is separated from *A. ritzema-bosi*, *A. subtenuis* and *A. besseyi* by the two lines in the wing area, the rather simple armature of the concoid tail and the lip region which is not expanded. *A. fragariae* can be distinguished from *A. parietinus* by the presence of well-developed knobs on the spear and the two lines in the wing area.

NEOTYPE: Female, collected from strawberry, Escalon, California, August 5, 1947. Cat. No. 16, University of California Nematode Survey Collection, Berkeley.

A. fragariae was described by Ritzema Bos (1891) from specimens secured from strawberry plants sent to him from England. The description presented by Ritzema Bos is rather meager but sufficient information is given to separate this species from other species known to occur on strawberry in England. The length and width measurements given by Ritzema Bos fall within the limits of those derived from study of the present material. In 1893 Ritzema Bos described *A. olesistus* from the leaves of fern. Subsequently several authors have indicated that they could find no morpohological characters that would separate these two species. However, it should be pointed out that because of mis-identification some authors may have been comparing *A. olesistus*=*A. fragariae* to *A. ritzema-bosi*. Marcinoski (1908) and Steiner (1932) regarded *A. olesistus* and *A. fragariae* as a single species on the basis of host transfers and the absence of distinguishing morphological characters. The views of these workers were not widely accepted because of the confusion that existed in England concerning the proper identification of *A. fragariae*. There can be no doubt that this name has been used extensively in the literature when the species concerned was actually *A. ritzema-bosi*. By placing *A. olesistus* as a synonym of *A. fragariae* most of the difficulties that have been encountered in the identification of the bud and leaf nematodes are easily resolved.

Aphelenchoides pseudolesistus (Goodey,1928) is here regarded as a synonym of *A. fragariae*. Goodey (1928) indicated that *A. pseudolesistus* was morphologically identical with *A. olesistus* = *A. fragariae*. His reason for separating the two forms being that he found *A. pseudolesistus* associated

with decaying oak leaves and galls on chrysanthemum rootstock. In view of the work of Christie and Crossman (1936) in which they demonstrated that it is possible to rear some species of leaf and bud nematodes on agar plates inoculated with fungi it seems best to regard *A. pseudolesistus* as a synonym of *A. fragariae* in the absence of differentiating morphological characters. *A. olesistus* var. *longicollis* was described as having a longer neck region than the species. However, measurements of specimens of *A. fragariae* from strawberry plants indicate that the variation in neck length is sufficient to include the variety *longicollis* and this form is also to be placed in synonymy with *A. fragariae*.

A study of specimens of *A. fragariae* from strawberry, Croft lily, bird's-nest fern, daffodil, violets, and begonia indicates that the only variation encountered in these populations is one of size and this is not consistent within a single population. The position of the excretory pore and the length of the posterior uterine branch are as variable within populations as between populations. Extreme care should be exercised by future workers before additional species showing close affinities to *A. fragariae* are described.

Aphelenchoides ritzemi-bosi (Schwartz, 1912) Steiner, 1932 (Fig. 2, A-F).

Synonyms:

Tylenchus ribes, Taylor, 1917.
Aphelenchus ribes, Goodey, 1923 (J. Helm. 1:143-156).
Aphelenchoides ribes, Goodey, 1933.
Aphelenchus phylloghagus, Stewart, 1921.

Females*: L, 0.77-1.2 mm.; a, 40-54; b, 10-13; c, 18-24; V, $^{48\text{-}33**}$ $66\text{-}75.^{14\text{-}17***}$

Males*: L, 0.70-0.93 mm.; a, 31-50; b, 10-14; c, 16-30; T, 35-64.

Female (Neotype): Length 0.85 mm.; a—42; b—12; c—18; vulva 68%; ovary 35%; posterior uterine branch 17% (7.2 times body width). Body slender. Cuticle marked by fine transverse striae. Lateral field about one-fifth as wide as body diameter, marked by four incisures. Lip region expanded, wider than neck at base of lips. Lips without annulation. Six-radial framework of lip region delicate. Cheilorhabdions near oral aperature moderately sclerotized and appearing as cuticularized pieces. Spear 12 μ long, slender, with well-developed basal knobs. Median esophageal bulb well developed. Nerve ring 1½ body widths behind median bulb. Excretory pore located behind nerve ring. Esophageal glands extending 4 body widths behind median bulb, joining esophagus immediately behind median bulb. Anterior end of intestine a slender tube, joining esophagus immediately behind median bulb. Oocytes not arranged in tandem, several in a cross-section at middle of ovary. Posterior uterine branch usually containing spermatozoa. Tail tapering conoid. Terminus peg-like armed with four small mucronate points.

Male: Male tail curvature about 180 degrees when relaxed by gentle heat. Three pairs of ventro-submedian papillae. First pair adanal, second midway on tail, third near end. Spicules ventrally curved, the ventral piece without a ventral process at the distal end.

Diagnosis: *A. ritzema-bosi* can be separated from *A. fragariae* by the

*See footnote on page 109.
**See footnote on page 109.
***See footnote on page 109.

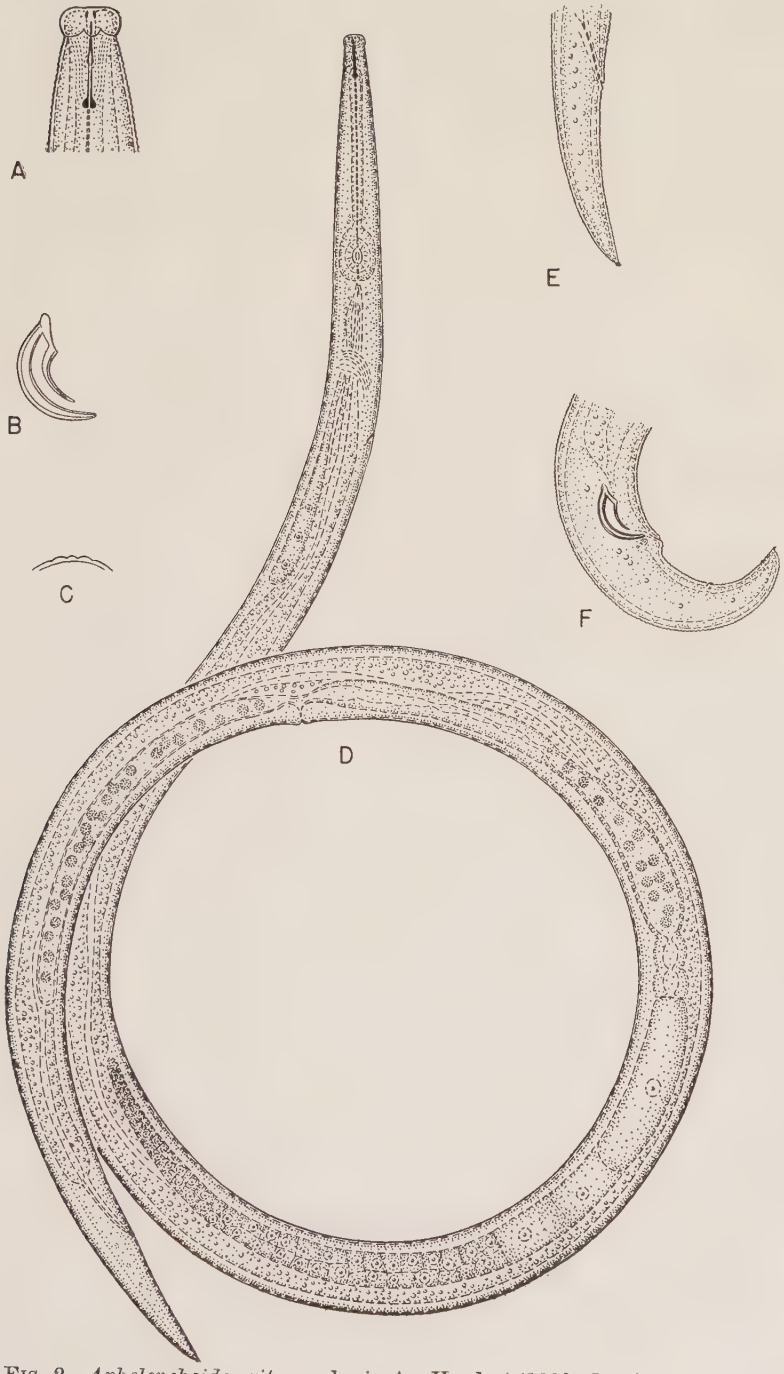

FIG. 2. *Aphelenchoides ritzema-bosi.* A—Head; ×1000. B—Spicule; ×1000. C—Lateral field; ×1000. D—Female; ×500. E—Female tail; ×500. F—Male tail; ×500.

presence of four lines in the wing area, larger size, expanded lip region, position of the excretory pore and the presence of four small mucronate points on the peg-like terminus of the tail. It is distinguished from *A. besseyi* by the longer posterior uterine branch, position of the excretory pore, and shape of the spicules. *A. ritzema-bosi* differes from *A. subtenuis* in the position of the excretory pore and the armature and shape of the female tail.

Neotype: Female collected from chrysanthemum, Redwood City, California, August 19, 1941. Catalogue No. 17. University of California Nematode Survey Collection, Berkeley.

The difficulties that have arisen concerning the identification of *A. ritzema-bosi* have been primarily due to the confusion of this species with *A. fragariae*. A number of the illustrations presented in the literature as *A. fragariae* were without doubt made from specimens of *A. ritzema-bosi* (Goodey, 1928 and 1933). Most of the literature indicates that the species of bud and leaf nematodes are more or less host specific and as a result numerous identifications have been based entirely upon the host plant from which the specimens were collected. It now appears that these species may be highly polyphagus and proper identifications can only be made upon morphological characters. *A. ribes* (Taylor, 1917) appears as an example of an identification based upon host affinities. It has been noted by Goodey (1928 and 1933) and Franklin (1950) that this species is morphologically indistinguishable from *A. ritzema-bosi* but because *A. ribes* did not transfer to hosts known to be susceptible to *A. ritzema-bosi* it was considered to be a separate and distinct species. Franklin (1950) has reported the successful transfer of nematodes identified as *A. ribes* from black currant to strawberry and *A. ritzema-bosi* from strawberry to black currant. The fact that typical symptoms were not observed were cited by this author as the only evidence to indicate that *A. ribes* and *A. ritzema-bosi* were separate species. The transfer of bud and leaf nematodes from one host to another is frequently very difficult experimentally and the number of nematodes successfully making the transfer materially affects the time required for the increase in population that is required before symptoms are considered typical. In this laboratory we have frequently experienced difficulty in transferring these nematodes back to the original host plant and reestablishing the population to the extent that typical symptoms become evident. Because of the absence of any distinguishing morphological characters and the fact that host plant transfers are possible on occasion, *A. ribes* is considered to be a synonym of *A. ritzera-bosi.*

Specimens of *A. ritzema-bosi* from the following localities and hosts have been examined and compared without finding morphological characters that would make it possible to distinguish among the various populations: *Campanula rapunculoides* L., chrysanthemum, gooseberry, gloxinia, lupine, *Mimulus guttatus* D. C., *Saintpaulia,* strawberry, and watermelon Peperomia from the United States; blackcurrant, chrysanthemum and strawberry from England. Attention should be called to the fact that there is considerable variation in size of males and females. However, there is sufficient overlap in the measurements so that the variation is continuous between populations. The length of the posterior uterine branch and the position of the excretory pore are somewhat variable but here again the evidence secured from the examination of numerous specimens from the above host plants is indicative of within-species variation. The excretory pore is always behind the nerve ring, varying

in position from one-half to two body widths behind the nerve ring. The mucronate points on the peg-like terminus of both male and female tails show variation in size and shape. The curvature of the male tail usually approximates 180 degrees but occasional specimens are encountered with greater or lesses curvature of the tail. The curvature of the male tail is not a reliable character to use for species determinations unless used in conjunction with other less variable morphological features of the species.

Aphelenchoides besseyi Christie 1942 (Fig. 3, A-G)

SYNONYM:

Aphelenchoides oryzae Yokoo, 1948. Ann. Phytopath. Soc. Japan, 13: 40-43. (N. Syn.)

FEMALES*: L, 0.62-0.88 mm.; a, 38-58; b, 9-12; c, 15-20; V, 43-33** 66-72. 4-8***

MALES*: L, 0.44-0.72 mm.; a, 36-47; b, 9-11; c, 14-19; Testis 50-65%.

FEMALE (Neotype): Length 0.7 mm.; a—50; b—10; c—19; Vulva 70%; ovary 33%; posterior uterine branch 6% (3 times body width). Body slender. Cuticle marked by fine striae. Lateral field occupying one-fourth of body diameter, marked by four incisures. Lip region expanded, wider than neck at base of lips. Lips without annulation. Six-radial head sclerotization delicate. Cheilorhabdions near oral aperture moderately sclerotized, and appearing as dark cuticularized pieces. Spear 10 μ long with moderately well-developed knobs. Median esophageal bulb well developed. Nerve ring one body width behind median bulb. Excretory pore located anterior to nerve ring. Esophageal gland extending 5 body widths behind median bulb, joining esophagus immediately behind median bulb. Intestine joining the esophagus as a slender tube immediately behind median bulb. Ovary relatively short. Oocytes not arranged in tandem, several in a cross section. Posterior uterine branch short, narrow, usually not containing spermatozoa. Tail tapering conoid. Terminus armed with four mucronate points. Mucrons usually divergent, with star-shaped appearance.

MALE: Male tail curvature about 180 degrees when relaxed by gentle heat. Three pairs of ventro-submedian papillae, the anterior pair being adanal. Spicules ventrally curved. The ventral piece with a moderate ventral process at the distal end. Terminus armed with four variable mucronate points.

DIAGNOSIS: *A. besseyi* is distinguished from *A. fragariae* by the shorter posterior uterine branch, the presence of four lines in the wing area, the four mucrons on the tail and the slightly expanded lip region. *A. besseyi* differs from *A. ritzema-bosi* by having the excretory pore located anterior to the nerve ring and a shorter posterior uterine branch. *A. besseyi* differs from *A. subtenuis* in having the four mucronate points on the tail and a shorter posterior uterine branch.

NEOTYPE: Female collected from strawberry, Florida, 1949 by J. R. Christie. Catalogue No. 19, University of California Nematode Survey Collection, Berkeley.

Yokoo (1948) described *A. oryzae* as a parasite of rice in Japan. The disease caused by this nematode had apparently been known in Japan as early as 1935 and was referred to as "abnormal growth of paddy rice." In June 1949, Dr. E. M. Cralley, Plant Pathologist, Arkansas Agricultural Experi-

*See footnote on page 109.
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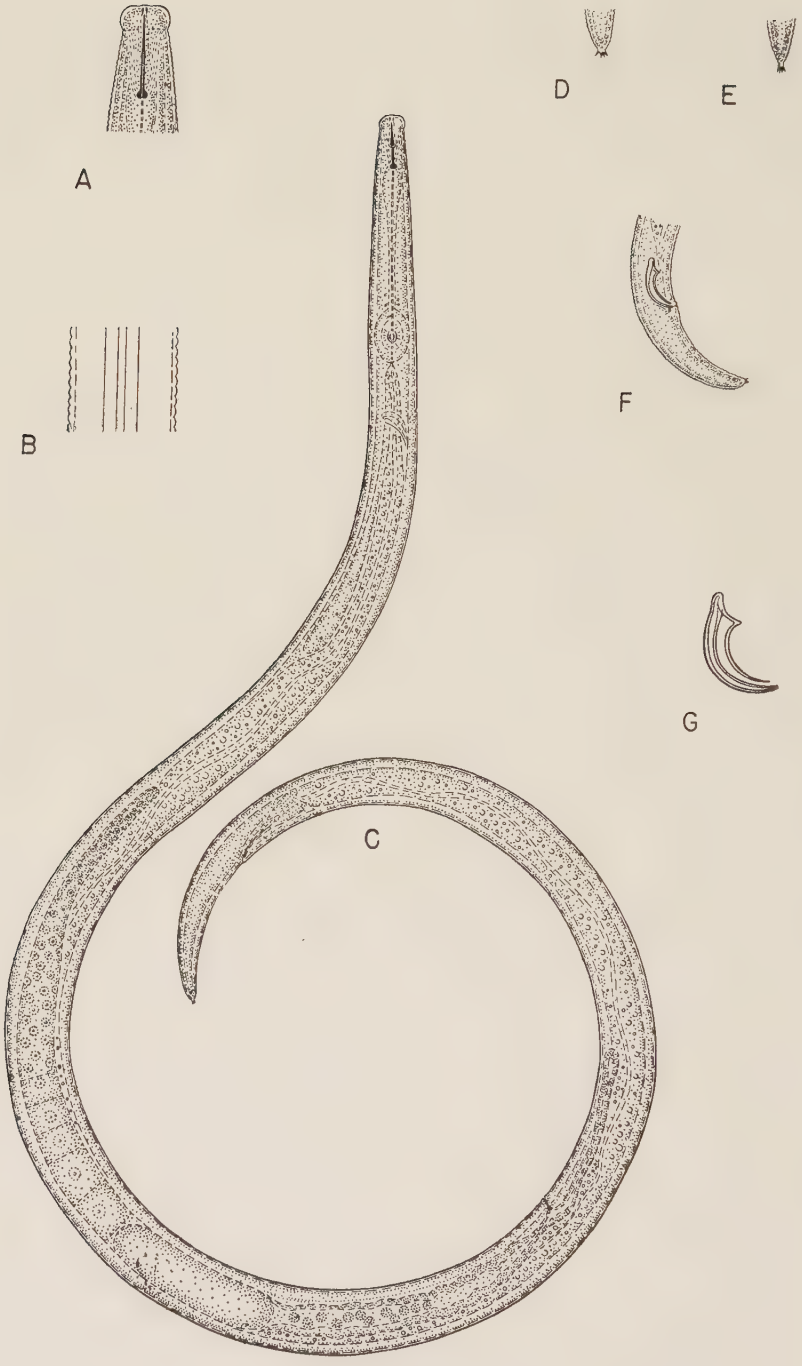

Fig. 3. *Aphelenchoides besseyi*. A—Head; ×1000. B—Lateral field; ×1000. C—Female; ×500. D and E—Female tail terminus; ×1000. F—Male tail; G—Spicule; ×1000.

ment Station at Fayetteville sent to the author specimens of an *Aphelenchoides* sp. which he considered to be the casual agent of white tip of rice in Arkansas. Dr. Cralley considered this rice disease to be very similar to that reported in Japan. Subsequently in April 1951 Mr. Minoru Ichinohe, Junior Nematologist of the Hokkaido National Experiment Station, Kontoni, Sapporo, Japan, supplied the author with specimens of *A. oryzae* from Japan. The specimens from Arkansas proved to be identical with the Japanese species. The parasite from rice is not morphologically distinguishable from specimens of *A. besseyi* obtained from Dr. Christie. It is therefore the opinion of the author that *A. oryzae* Yokoo is a synonym of *A. besseyi* Christie.

In March 1950, Dr. J. W. Hendrix, Plant Pathologist of the Hawaiian Agricultural Experiment Station submitted specimens of an *Aphelenchoides* species found infesting the buds of the Vanda orchid *Miss Joaquim* on the island of Hilo, T. H. These nematodes were tentatively identified as *A. ritzema-bosi.* However, when the specimens were compared with *A. besseyi* from strawberry and rice they proved to be morphologically identical in nearly all respects. The nematodes from Vanda orchid tend to be slightly larger than those from rice and strawberry and some specimens have the oocytes arranged in tandem. However, both types of oocyte arrangement are present in specimens of *A. besseyi* from rice and strawberry and it is doubtful if this can be considered as sufficient grounds for separating the Vanda orchid population from *A. besseyi.* The slightly larger size is not considered to be significant because there is considerable overlap in size among the populations examined. The population from Vanda orchid was readily inoculated into the leaves of *Saintpaulia* where it became endoparasitic in contrast to its ectoparasitic habit on the orchid. As has been pointed out by Franklin (1950) the endo- or ectoparasitic habit of nematodes in this group appears to be associated with the host plant type rather than being a physiological characteristic of a species. Rather than risk creating additional confusion in the taxonomy of this group of *Aphelenchoides* the author prefers to regard the Vanda orchid population as *A. besseyi.* This conclusion is based upon the presence of four lines in the wing area, short posterior uterine branch, same type of mucrons on the tail, excretory pore anterior to the nerve ring and the fact that variation of the oocyte arrangement in the ovary has been observed to occur in the rice, strawberry and Vanda orchid populations of this species.

Aphelenchoides subtenuis (Cobb, 1926) Steiner and Buhrer 1932

(Fig. 4, A-F)

SYNONYM:

Aphelenchoides hodsoni, Goodey, 1935 (Jour. Helm. 13:167-172).

FEMALES*: L, 0.87-1.15 mm.; a, 44-57; b, 12-17; c, 24-28; V,$^{58-44}$ 69-71.$^{12-16}$

MALES*: 0.87-0.95 mm.; a, 57-68; b, 12-14; c, 21-28; Testis 62-70%.

FEMALE (Neotype): Length 1.06 mm.; a—53; b—15; c—25; Vulva, 72%; ovary 58%; posterior uterine branch 14% (7.6 times body width). Body slender. Cuticle marked by fine transverse striae. Lateral field marked by four longitudinal incisures. Head set off, wider than neck at base of head. Lips without annulation. Six-radial sclerotized head framework delicate. Cheilorhabdions moderately sclerotized near oral opening, appearing as two cuticularized pieces laterally. Spear 11 μ long, knobs moderately well devel-

*See footnote on page 109.

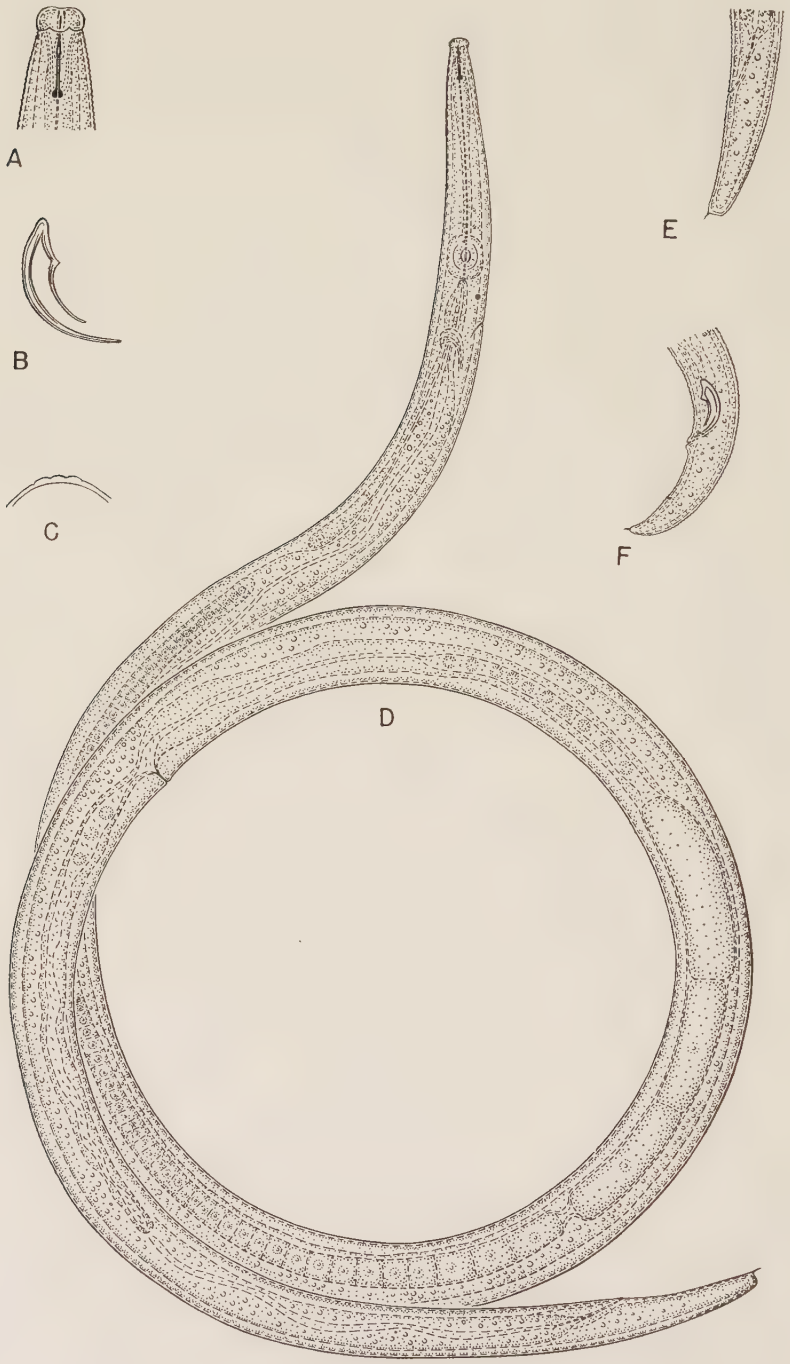

Fig. 4. *Aphelenchoides subtenuis.* A—Head; ×1000. B—Spicule; ×1000. C—Lateral field; ×1000. D—Female; ×500. E—Female tail; ×500. F—Male tail; ×500.

oped. Nerve ring one body width behind median bulb. Excretory pore located slightly anterior of nerve ring. Oocytes arranged in tandem. Posterior uterine branch long. Tail tapering gradually to blunt terminus armed with a single muchonate point located on the ventral side.

MALE: Curvature of tail about 180 degrees when relaxed by gentle heat, tapering to a bluntly rounded terminus armed with a single mucronate spine. Spicules ventrally curved. Ventral piece with a very small ventrally directed process at distal end. Three pairs of ventro-submedian papillae. One pair adanal, one pair at middle of tail, one pair near terminus.

DIAGNOSIS: *A. subtenuis* differs from *A. fragariae* in the armature of the female tail, larger size, number of lines in the wing area and shape of the head. It differs from *A. ritzema-bosi* in the shape and armature of the female tail and the location of the excertory pore. *A. subtenuis* differs from *A. besseyi* in having a longer posterior uterine brance, single mucronate spine on the tail and larger size.

NEOTYPE: Female collected from narcissus bulb in England by Dr. T. Goodey, April 5, 1925. Catalogue No. 18, University of California Nematode Survey Collection, Berkeley.

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Longevity of the Liver Fluke, *Fasciola* sp. in Sheep

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U. S. Bureau of Animal Industry, Beltsville, Maryland

On October 15, 1940, under the direction of Dr. Benjamin Schwartz, Chief of the Zoological Division, each of three sheep was given 110 metacercariae of the fluke commonly infesting the livers of cattle and sheep in the Gulf Coast area of Texas. No metacercariae were administered to these sheep at any subsequent time. The animals were placed in isolation cages at the Zoological Division's Beltsville, Maryland, station. Their chances of acquiring extraneous infection were very remote, since no case had ever been encountered there.

Fluke eggs were found in the feces of two of these sheep for the first time on January 4, 1941 (111 days after the administration of the metacercariae), and in the feces of the third sheep on January 7, 1941. Fecal samples were checked for eggs weekly by Messrs. Lawrence Avery and Harry Zimmerman until the 11th of July, 1945, 4½ years after the first eggs were noted.

One of the sheep died on September 11, 1948 and was autopsied on September 13 by Dr. G. Dikmans of the Zoological Division. This was 7 years and 11 months after it had been experimentally infected. Twenty-one flukes were recovered from the bile ducts and a large number of fluke eggs were recovered from the gall bladder. The liver weighed 1 lb., 9 oz., was pale in color and showed signs of degeneration. A calcareous cyst, about a half inch in diameter, was found in the body of the liver. No flukes were found in the gall bladder.

The second sheep died but was not autopsied, so far as the writer has been able to ascertain.

The last sheep died November 5, 1951, about 11 years after it was experimentally infected. At autopsy (by the writer), 15 flukes, representing 13.6 per cent of the metacercariae administered, were recovered from the bile ducts. Eggs were collected from the gall bladder and incubated at room temperature. Hatching was first observed 15 days later, well within the normal range of time for the escape of miracidia of *Fasciola*.

So far as can be ascertained, this is the longest period of time that liver flukes of the genus *Fasciola* have been harbored by sheep after a single administration of metacercariae. Taylor (Vet. Rec., 18:407, 1933) stated that 5¼ years was the longest time that liver flukes were known to have been retained by an animal without reinfection.

Some Observations on *Rictularia halli* Sandground 1935 (Nemotoda)

M. B. CHITWOOD
U. S. Bureau of Animal Industry

In the course of routine identification of specimens collected by Dr. D. J. Ameel and presented to the U. S. National Museum by Dr. George R. LaRue, the writer encountered an abundant supply of specimens of *Rictularia halli* Sandground, 1935. The host listed by Ameel was *Tamias striatus* and, although Sandground (1935, Trans. Am. Micr. Soc., v. 54:159-166) listed the host as *Eutamias striatus listeri,* it must be assumed that the latter was in error since both collections were made at Douglas Lake, Michigan, where *Eutamias* is not known to occur.

Superficial examination of the specimens revealed that Sandground had confused the laterodorsal papillae with the amphids and had not accounted for the lateroventral papillae and the ventroventral papillae of the external circle. Since the mouth opening of *Rictularia halli* is completely dorsal the verification of the basic papilla pattern, as demonstrated by Chitwood, B. G. and Wehr, E. E. (1934, Ztschr. Parasit. v. 7:273-335) is difficult. However by cutting off a head directly behind the mouth opening and mounting it with adequate support the writer was able to turn the head over and over and to rotate it while studying it under a microscope. While study with 10× oculars and an 8 mm. objective was adequate for most of the work, all findings were verified under an oil immersion objective.

The writer's observations and conclusions concerning the cephalic characters follow:

The anterior view, in which the mouth opening is not visible, shows four papillae of the internal circle in an almost straight line across the head just dorsal to the median line. The amphids are observed to be slightly more ventrad and external to the outer pair of internolateral papillae. The ventroventral papillae and the lateroventral papillae of the external circle are barely ventrad to the median line, the lateroventrals being greatly reduced in size (Fig. 1). The same eight papillae and the amphids may be observed in ventral view, the four internals appearing across the crest of the head with the amphids slightly posterior to the internolaterals (Fig. 2). One dorsodorsal papilla, one internodorsal, one internoventral, one ventroventral, one internolateral and one amphid may be seen in lateral view. The laterodorsal papilla is partially or completely obscured, depending upon the amount of pressure on the mount, by the large dorsodorsal papilla (Fig. 3). A dorsal view of the head shows all six papillae of the internal circle, the internolaterals and internoventrals along the crest of the head, the internodorsals just below the dorsal lip, the amphids slightly posterior and lateral to the internolateral papillae and the large dorsodorsals and the smaller laterodorsals on either side of the dorsal lip (Fig. 4). Thus the full component of 14 papillae and the two amphids is accounted for.

In the first two specimens studied, both in dorsal view, the writer was unable to account for the so-called esophageal tooth. Subsequent study revealed that this structure is visible only in lateral or sublateral view and is in reality not a tooth. As the head is rotated the "tooth" resolves into the sclerotized edge of the arched dorsal wall of the mouth cavity. The presence of actual teeth in other species of the genus has been observed.

Through the courtesy of the Harvard Museum of Comparative Zoology, Sandground's type specimens were available for comparison and a male and female from Ameel's collection have been designated hypotypes (U. S. National Museum No. 48250).

Despite numerous small variations, especially in size, through the two collections it was always evident that only one species was involved. There are three constant characters which are quite adequate to distinguish *R. halli* from other species from related hosts, the most distinctive being the extreme dorsality of the mouth opening. The small, delicate, and numerically constant spines and combs and the size of the small spicule are quite characteristic.

There are never less than 36 more often 37, rarely 41 pairs of spines and combs of which 27 to 28 are prevulvar, one at level of vulva and the remainder postvulvar. The transition from combs to spines is gradual, beginning 5 to 7 appendages anterior to the vulva. There is little actual variation in head characters.

In the five males studied the short spicule was constantly about half the length of the long spicule. However, one of the specimens had no ventral fans and one had only four. Since, according to Sandground (*loc. cit.*) the absence of fans is the main character distinguishing *R. coloradiensis* Hall 1916 from *R. halli*, the writer has studied Hall's type specimens and found

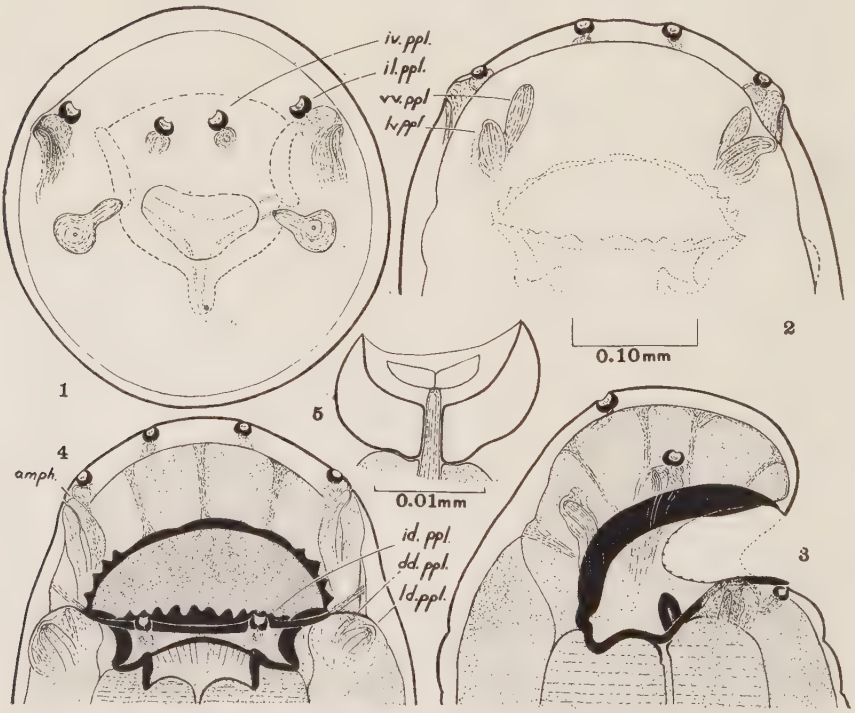

Plate I. Cephalic papillae of *Rictularia halli*

no more than generic similarities. The oral opening of *R. coloradiensis* is only slightly dorsal, the spicules are nearly equal and the large coarse spines and combs arranged in a closely contiguous series extend from just posterior to the head almost to the anus in the male and to approximately one fourth the body length from the anus in the female. While the number of spines and combs in the various species is extremely important it is not enough on which to base a species.

From examination of the several species of the genus *Rictularia* in the U. S. National Museum Collection, which includes representatives of the group in which the oral opening is terminal to subterminal and of the group of species in which the oral opening is dorsally inclined, the writer concludes that the crescentic papillae of the internal circle are always present and may be characteristic of the genus. These papillae appear to be much more prominent in those species with dorsally inclined oral openings. The writer makes no attempt to explain the mechanism of these papillae but rather presents a drawing of her concept (Fig. 5).

Natural Infection of an Egyptian Gerbil with *Schistosoma mansoni*[1]

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In the Orient mammals are frequently, if not commonly, infected with *Schistosoma japonicum* in regions where schistosomiasis is prevalent. Natural infection of pigs, deer, cattle, dogs and cats occur to such an extent as to play a part in the epidemiology of the disease. On the contrary reservoir hosts, other than monkeys (Cameron, 1928) have never been reported for *S. mansoni* or *S. haematobium*.

Experimental schistosomiasis in various laboratory animals, demonstrating considerable ranges of susceptibility, has been reported by Moore, Yolles and Meleny (1949), Stirewalt, Kuntz, and Evans (1951) and others. A comparable pattern of susceptibility to *S. mansoni*, under laboratory conditions, has been shown for rodents taken from the vicinity of Egyptian villages, as well as in certain species of desert rodents occurring in Egypt (unpublished manuscript.) The latter finding suggested the possibility of such hosts serving in the capacity of reservoir hosts for *S. mansoni*. However, an examination of approximately 200 small mammals (*Acomys*, spiny back mouse; *Arvicanthis*, the Nile rat; *Crocidura*, Flower's shrew; *Mus*, house mouse; and *Rattus*, house rat) trapped or killed in the vicinity of villages known to have a high incidence of schistosomiasis has yielded no schistosomes. This is somewhat surprising since certain of the host species examined, particularly *Arvicanthis*, can be readily infected with *S. mansoni*

[1]The opinions or assertions contained therein are the private ones of the writer and are not to be construed as official or reflecting the view of the Navy Department or the naval service at large.

The author is indebted to Harry Hoogstraal, Head, Department of Medical Zoology for cooperation in making hosts available for examination, and to George M. Malakatis for technical assistance.

in the laboratory. In addition, observations in the field have indicated that *Arvicanthis* spends some time along the edges or irrigation and drainage canals, and occasionally swims in the water.

Although several species of desert gerbils (*Gerbillus* and others) and the jerboa (*Jaculus*) are moderately susceptible to infection by *S. mansoni* under laboratory conditions, one would not expect such animals to be infected in nature, since these rodents require very little moisture and may survive for days in absence of drinking water. However, in the routine examination of mammals for their helminth parasites a single *Gerbillus p. pyramidum* Geoffrey taken approximately 20 miles northwest of Cairo, Egypt (Nov. 1950) possessed three immature female schistosomes, identified as *S. mansoni,* in the vessels of the portal system.

It seems possible that this rodent may have become infected by eating a *Biomphalaria boissyi* infected with *S. mansoni.* Snails occasionally are stranded on canal banks or in fields following the drop in water level after the annual Nile flood. This supposition is further supported by the fact that the worms found in the gerbil in November, four to five weeks after the flood, were immature. Furthermore all three worms were of the same sex indicating that the infection might have come from a single snail. Experiments in the laboratory have shown that *G. pyramidum* will eat living snails.

Although it has been known for quite some time that rodents or other mammals might possibly serve as reservoirs for the schistosomes of man this is the first record of a natural infection of *S. mansoni* in rodents. Such a finding indicates the possible seriousness of reservoir hosts should satisfactory conditions prevail.

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Gongylonema pulchrum, a spirurid nematode infecting man in Illinois, U. S. A.

Lyell J. Thomas

On May 12, 1950, a 20-year old male student at the University of Illinois, came to the author's laboratory with a live worm in sputum. Six months prior, the worm was felt moving about in his lips and cheeks. On the date mentioned the worm partly emerged from the mucus membrane of his lower lip. Grasping it with his fingers, he removed it intact. It was found to be a nearly mature female *Gongylonema pulchrum* with developing eggs.

The student had been in Mexico in the summer of 1948. He did not recall drinking from springs or streams while in Mexico but had eaten in hotels where salads were on the menu. He was born and raised in Benton, Illinois, and had enjoyed camping trips in that area near his home every summer. At such times he had taken water directly from springs.

It is probable that this young man obtained his infection from drinking water or food. Baylis (1939) noted that the third stage larvae of *Gongylonema pulchrum* emerge from the dead bodies of insects when they are placed in water and may live for several days. Ransom and Hall (1915) infected various dung beetles collected from sheep manure. Cockroaches, *Blattella germanica,* will serve as intermediate hosts.

Gongylonema pulchrum is common in hogs in Europe and the United States. It has also been found in African swine by Seurat (1912). Gaud and Chabaud (1951) reported the first case of *Gongylonema pulchrum* infecting humans in Africa and the fifteenth case in the world. Crusz and Sivalingam (1950) reported the fourteenth case in Ceylon of this same worm which on February 4, 1948, was extracted by the man himself from the tissues of his mouth between the lower jaw and cheek.

This report of *Gongylonema* from an Illinois boy is the seventh case reported in the United States from man and the sixteenth for the world. The first case in the United States was reported by Ward (1916) from the lower lip of a girl from Nebraska. Since then Stiles (1918, 1920, 1921), Ransom (1923), Stiles and Baker (1928), and Waite and Gorrie (1935) have reported human infections in the United States.

Chandler (1950) in his description of *Gongylonema pulchrum* taken from the tongue of a black bear from Pennsylvania, U.S.A., called attention to the fact that *G. pulchrum* may be synonymous with *G. ursi* reported from the bear in Europe. Not until someone examines the type species in the Vienna museum will it be settled.

The measurements of the immature female worm from the Illinois boy are similar to those of the worms Chandler obtained from the bear. The length of the immature female worm from the Benton, Illinois young man is 28.4 mm.; diameter of body 0.176mm. at vulva; length of oesophagus 5.219 mm.; tail length 0.167 mm. from anus; width at anus 0.086 mm.; vulva from posterior end 3.192 mm.; left cervical ala from anterior end 0.014 mm.; cuticular bosses extend 1.285 mm. from the anterior end; cuticular striations are 20 μ apart; diameter of the buccal rim 0.028 mm.; length of pharynx 0.042 mm.; cervical papillae from anterior end 0.127 mm.; nerve ring from anterior end 0.277 mm., width at nerve ring 0.093 mm.; eggs 21 $\mu \times 14$ μ. The female worms described by Chandler are 41-55 mm. in length; 0.240-0.260 mm. in greatest body diameter; esophageal length 0.200-0.250 mm.; vulva 1.6-2.1 mm. from posterior end; eggs 54 μ-50 $\mu \times 30$ μ-33 μ. In general appearance they are the same although the measurements of the worms from the bear show them to be more mature and larger.

The immature female *Gongylonema pulchrum* has been cataloged as U.S.N.M. Helm. Coll. No. 47337.

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Longibucca lasiura, McIntosh and Chitwood, 1934; New Host Records

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Longibucca lasiura was originally described from the bat, *Lasiurus borealis* (Muller 1776), taken in the vicinity of Washington, D. C. (Parasitology 26:1 138-140). In a note appended to the original description the authors report the occurrence of this nematode in *Eptesicus fuscus fuscus* (Beauvois 1796), also collected in Washington, D. C. These appear to be the only previous host records for *Longibucca lasiura.*

The new hosts recorded are the long eared bat, *Corynorhinus rafinesquii rafinesquii* (Lesson) and the little brown bat, *Myotis lucifugus lucifugus* (LeConte, 1831). Both were taken from a cave in Pendleton Co., West Virginia. Nine long eared bats were examined and three were found to be infected. In all cases the nematodes were found only in the stomach, attached to the mucosa. None of the infections were heavy; the maximum number found in any one bat being approximately 16. Of 60 *Myotis l. lucifugus* examined only 6 were found to be infected with *L. lasiura;* again they were found only in the stomach. The infections in the little brown bat were invariably heavier, a maximum of approximately 30 worms being recovered from one bat.

Minutes

THREE HUNDRED FIRST TO THREE HUNDRED EIGHTH MEETINGS

The 301st meeting was held at McMahon Hall, Catholic University of America, Washington, D. C. on October 17, 1951. The resignation of Dr. E. G. Reinhard as Editor of the Proceedings was accepted with thanks for his excellent work in this capacity for the past four years. The following were elected to membership: Dr. George Anastos, Mr. Francis G. Tromba,

Mr. Frank William Douvres, Mr. Willard N. Smith, Mr. G. Robert Lange, Mr. Joseph C. Hwang, Mr. Samuel A. Sher, and Mr. William J. Hargis. Papers were presented by Dr. G. Steiner and Father R. W. Timm.

The 302nd meeting was held in the Library of the Zoological Division of the Bureau of Animal Industry, Beltsville, Maryland, on November 30, 1951. Upon announcement of the resignation of Dr. E. W. Price and Dr. Gotthold Steiner, and the expiration of the term of membership of Dr. W. H. Wright of the Editorial Committee, Dr. A. O. Foster, Mr. A. L. Taylor, and Dr. L. J. Olivier were unanimously elected to replace them. The Committee named Dr. Gilbert F. Otto as Editor of the Proceedings. A vote of thanks was extended by the Society to the retiring Editor, Dr. E. G. Reinhard. The following were elected to membership: Mr. Kenneth A. Nieland, Dr. Gorge L. Graham, Mr. John L. Gardiner, Dr. Victor H. Dropkin, Dr. Pedro Kouri, Dr. J. F. A. Sprent, Mr. Louis S. Diamond, and Dr. Lloyd E. Rozeboom. Dr. Price introduced the speakers: Dr. G. Dikmans, Dr. M. L. Colgazier, Mrs. M. B. Chitwood, Dr. George Anastos, and Mr. C. H. Hill.

The 303rd meeting was held at McMahon Hall, Catholic University of America, on December 19, 1951. The officers elected to serve during the year 1952 were: Dr. Leon Jacobs, President; Dr. Norman A. Meinkoth, Vice President; Dr. M. A. Stirewalt, Recording Secretary; Miss Edna M. Buhrer, Cor.-Secretary and Treasurer. The following were elected to membership: Dr. Philip E. Smith and Miss Naomi Hawkins. Papers were presented by Dr. G. W. Hunter and Miss Naomi Hawkins.

The 304th meeting was held at McMahon Hall, Catholic University of America, on January 23, 1952. Two members-at-large were appointed to fill vacancies on the Executive Committee: Dr. von Brand, and Dr. Dikmans. Dr. L. A. Spindler was elected to represent the Society in the Washington Academy of Science. Papers were presented by Dr. K. C. Kates and Dr. Gilbert F. Otto.

The 305th meeting was held at McMahon Hall, Catholic University of America on February 20, 1952. Papers were presented by Dr. E. G. Reinhard, Dr. C. M. Herman, Dr. Leon Jacobs and Dr. B. G. Chitwood.

The 306th meeting was held in Wilson Hall, National Institutes of Health, Bethesda, Maryland, on March 19, 1952. The following were elected to membership: Capt. Charlie N. Barron, U. S. A., Dr. Robert-Ph. Dollfus, Mr. Robert G. Grocott, Dr. Svetozar Teodorovich, and Dr. F. J. Spruyl. Papers were presented by Dr. Willard H. Wright, Dr. W. L. Newton and Dr. Paul Weinstein.

The 307th meeting was held at the Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland, on April 18, 1952. In recognition of his many contributions to Parasitology, Dr. W. W. Cort was unanimously elected to life membership in the Society. The following new members were elected: Mr. Robert C. Wallis, Mr. Ralph Thorson, Miss Alice Richards, Mr. Robert M. Chute, Dr. Lawrence R. Penner, Mr. J. Robert Buchheit, and Dr. Merle F. Hansen. Dr. Cort introduced the speakers: Mr. Barr, Miss Richards, Mr. Thorson, Mr. Wallace, Lt. Jachowski, U.S.N., and Dr. Werk.

The 308th meeting was a picnic held at the cafeteria-log cabin of the Agricultural Research Center, Beltsville, Maryland, on May 17th, 1952. The following new members were elected: Dr. Walter L. Newton and Mr. Robert Jennings.

M. A. STIREWALT
Recording Secretary

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